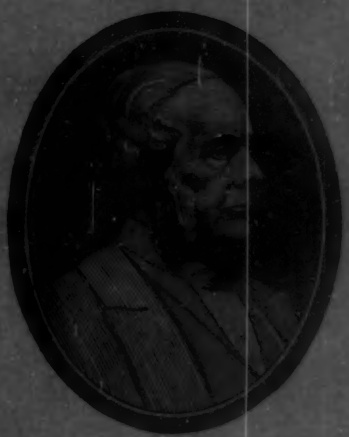
VOL. XLII ISSUED IN ALTERNATE MONTHS No. 173

HOSPITAL LIBRARY

# The British Journal of Surgery



LISTER

UNIVERSITY OF MICHIGAN
FEB 1 1955
MEDICAL LIBRARY

## NOVEMBER, 1954

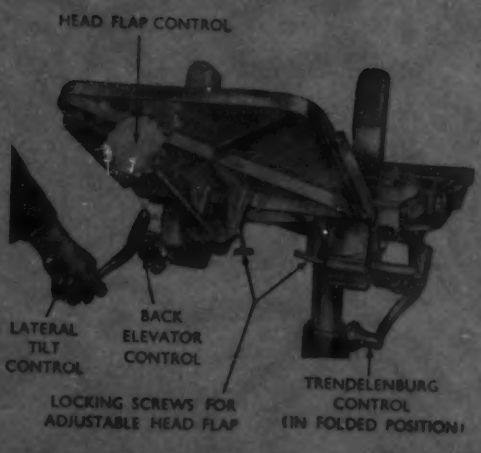
BRISTOL: JOHN WRIGHT & SONS LTD.
WHOLESALE DISTRIBUTORS: WM. DAWSON & SONS LTD.
10-12 MACKLIN STREET, LONDON W.C.2.
UNITED STATES OF AMERICA: THE WILLIAMS & WILKINS COMPANY, BALTIMORE, Sole Agents
Entered as second class matter at the Post Office at BALTIMORE under Act of March 3, 1879.

# HEAD END CONTROL

## *with* RIGIDITY

Incorporating head-end control with no sacrifice of rigidity, enabling all major adjustments to the position of the table to be made without interruption of the surgical team, the new A & H Model J Operation Table has been specially designed to meet the exacting requirements of modern surgical technique.

In this Operation Table, with its many improvements and its unlimited versatility, undisputed leadership in design is uniquely allied to the reliability, craftsmanship and quality which have been associated with the name Allen & Hanburys for over 200 years. An illustrated manual will be supplied on application.


HEAD FLAP CONTROL
LATERAL TILT CONTROL
BACK ELEVATOR CONTROL
LOCKING SCREWS FOR ADJUSTABLE HEAD FLAP
TRENDELENBURG CONTROL (IN FOLDED POSITION)

*Manufactured in England by*

ALLEN & HANBURYS LTD LONDON E2

*Makers of Quality Instruments*

SHOWROOMS: 48 WIGMORE STREET LONDON W1

# The British Journal of Surgery

## *CONTENTS, NOVEMBER,* 1954

### ORIGINAL PAPERS


| | PAGE |
|---|---|
| The Expanding Scope of Cardiovascular Surgery - - - - - - *Alfred Blalock* | 225 |
| Hiatus Hernia - - - - - - - - - - - - *N. R. Barrett* | 231 |
| Epithelioma Cuniculatum - - *Ian Aird, H. Daintree Johnson, Bernard Lennox, and A. G. Stansfeld* | 245 |
| Observations on the Vascularization of the Human and Rabbit Thyroid Gland - *T. D. Reilly* | 251 |
| Metastatic Hypernephroma of the Thyroid Gland - - *G. Gordon Bruce and W. Michie* | 257 |
| Granuloma Silicoticum caused by Kaolin Poultice - - *George Armitage and Irvine Smith* | 263 |
| Ileovesical Fistula - - - - - - - - - - *W. R. Black and D. E. Bolt* | 265 |
| Malignant Tenosynovioma (Fibrosarcoma) with Twenty-three Years' Survival *Ronald G. Henderson and R. G. Main* | 268 |
| Irreducible Inguinal Herniæ in Children - - - - - - - *Irvine Smith* | 271 |
| Subcostosternal Hernia (Hernia through the Foramen of Morgagni) *Raymond Helsby and Charles Wells* | 274 |
| Venography and the Approach to Varicose Veins *Ian F. K. Muir, Eric H. Mucklow, and Anthony J. H. Rains* | 276 |
| Use of Left Colon for Reconstruction of Pharynx and Œsophagus after Pharyngectomy *J. C. Goligher and Ian G. Robin* | 283 |
| The Use of an Isolated Length of Ileum as a Urinary Channel *David Annis, W. R. Hunter, and Charles Wells* | 290 |
| Sacralization: An Aetiological Factor in Lumbar Intervertebral Disk Lesions, and a Cause of Misleading Focal Signs - - - - - - - - - - *John Andrew* | 304 |
| Acrylic Cranioplasty - - - - - - - *R. G. Robinson and A. D. Macalister* | 312 |


### EXPERIMENTAL SURGERY


| | |
|---|---|
| Some Physical Properties of Vascular Grafts - - - - - - *R. Warwick-Brown* | 316 |
| Experimental Mitral Incompetence in Dogs: Studies in Hæmodynamics *G. R. Crawshaw, V. H. Wilson, L. Kreel, K. B. Vetten, and J. B. Borman* | 319 |


### SHORT NOTES OF RARE OR OBSCURE CASES


| | |
|---|---|
| Fibrocystic Salivary Tumour of the Mandible - - - - - *Alister J. M. Mathieson* | 327 |
| Duodenorenal Fistula: A Complication of Peptic Ulceration - - *Francis E. Stock* | 330 |
| Strangulated Femoral Hernia in an Infant Boy aged Five Weeks - - *Betty M. L. Underhill* | 332 |


### REVIEWS AND NOTICES OF BOOKS


Illustrated Review of Fracture Treatment—*Frederick Lee Liebolt.* Maxillo-facial Laboratory Technique and Facial Prostheses—*Stanley Brasier.* Surgical Infections—*Edwin J. Pulaski.* The Painful Phantom—*Lawrence C. Kolb.* The Anatomy and Surgery of Hernia—*Leo M. Zimmerman and Barry J. Anson.* Varicose Veins—*R. Rowden Foote.* Surgery of the Cæcum and Colon—*Stanley Aylett.* Carcinoma of the Colon—*Leland S. McKittrick and Frank C. Wheelock.* Textbook of Chiropody—*Margaret J. McKenzie.* Demonstrations of Operative Surgery—*Hamilton Bailey.* Anatomy, Regional and Applied—*R. J. Last.* Cancer, Diagnosis, Treatment, and Prognosis—*Lauren V. Ackerman and Juan A. del Regato.* The Anatomy of the Bronchial Tree—*R. C. Brock.* Roentgen-diagnostics—*H. R. Schinz, W. E. Bæsnsch, E. Friedl, and E. Uehlinger.* Surgical Forum: Proceedings of the Forum Sessions Thirty-ninth Clinical Congress of the American College of Surgeons, Chicago, Illinois, October, 1953—*Various Authors.* Tumours of Lymphoid Tissue—*George Lumb.* Proceedings of the First World Conference on Medical Education, London, 1953—ed. *Hugh Clegg.* Sympathikus Chirurgie—*Paul Sunder-Plassmann* - - - - - - - - - - 333

# *EDITORIAL NOTICES*

EDITORIAL COMMUNICATIONS should be addressed to the *Editorial Secretary, British Journal of Surgery, c/o John Wright & Sons Ltd., Bristol,* 8.

Original Articles are invited, and may be sent if desired to any other member of the Editorial Committee: they are accepted with the understanding that they are contributed to this Journal only, and that articles and their illustrations become the property of the Journal unless the authors state, before publication, that they reserve the rights to themselves.

REPRINTS.—The Publishers regret that they are no longer able to supply these free of charge. If authors will kindly notify the number of copies required they will be supplied at the cost of production, and 50 copies are suggested as the minimum.

BUSINESS COMMUNICATIONS should be addressed to *John Wright & Sons Ltd., British Journal of Surgery, Bristol,* 8. Remittances should be made payable to *The British Journal of Surgery.*

BINDING.—Handsome Cloth Cases may be obtained for binding Vol. xli. Cases are also available for some of the earlier volumes. Application should be made to the Publishers, who will also undertake the binding if desired. Case 7s. 6d., post 8d.; Case and binding 17s. 6d., post free.

BACK NUMBERS.—The Publishers would be glad to purchase copies in good condition of Nos. 111, Vol. xxviii, 125, Vol. xxxii, 132, Vol. xxxiii, and 133–135, Vol. xxxiv and also Vol. 1 complete (either bound or as Nos. 1–4).

---

## INSTRUCTIONS TO AUTHORS

PREPARATION OF MS.—Papers should be submitted in typescript and the author should retain a carbon copy. Double spacing should be used throughout, except for quotations.

TABLES AND ILLUSTRATIONS.—Tables should be numbered in roman numerals and set out on sheets separate from the text. Illustrations, too, should be kept separate from the text and should be numbered consecutively in arabic numerals. Each figure should be referred to in the text, and the descriptive legends should be typewritten on a separate sheet of paper, and not put on the backs of the originals. Glossy photographs should be supplied and prints should be sent whenever possible in preference to X-ray negatives. Drawings should be in a finished state suitable for reproduction.

REFERENCES.—The Harvard System should be followed.

In this system the name of the author and the date of the publication are given in the text; the list of authors quoted is put at the end of the article in alphabetical order. Each reference in the list should give, in order, the author's name, initials, the year of publication (in brackets), the full title of the paper,* the name of the journal, the volume (in heavy type arabic numerals), and the number of the first page of the paper. If the author cited has written more than one paper in the year, each should be distinguished by the letters a, b, and c, etc. For books, the place of publication should be stated and the publisher's name. The names of collaborating authors should be given in full on the first occasion, but in later citations the words "and others" should follow the first name.

Abbreviations for journals should be those adopted in the "WORLD LIST OF SCIENTIFIC PERIODICALS" (1934).

Only in papers in which many and frequent references have to be made should the items be numbered; the numbers may then be inserted in the text without interrupting it with a list of names.

---

* As an economy at the present time, the title of the paper may be omitted.

THE
BRITISH JOURNAL OF SURGERY

VOL. XLII NOVEMBER, 1954 No. 173

# THE EXPANDING SCOPE OF CARDIOVASCULAR SURGERY*

BY ALFRED BLALOCK, BALTIMORE, MD.
FROM THE DEPARTMENT OF SURGERY OF JOHNS HOPKINS UNIVERSITY AND HOSPITAL

THE honour of giving a Moynihan Lecture in Leeds will be appreciated always. Lord Moynihan led an amazingly interesting and productive life. Even in the British Isles, which has produced so many eminent scientists, this surgeon was outstanding. Born in Malta in 1865 and reared in Leeds, he was professor of clinical surgery at Leeds from 1909 to 1926. An extremely capable and versatile surgeon, speaker, teacher, and writer, he exerted an important influence on British and on world surgery. He was President of the Royal College of Surgeons of England from 1926 to 1932, the second and last provincial surgeon to hold this office, the first having been Joseph Hodgson of Birmingham in 1864. Lord Moynihan exercised important roles in World War I, in the work of the Royal College, in the founding of the BRITISH JOURNAL OF SURGERY, in helping to create the Buckston Browne Experimental Farm, and in the work of the association meeting here this week. As most of you know, a sectional meeting of the American College of Surgeons is to be held in London next week. Lord Moynihan became an honorary member of this organization in 1917, at which time he gave the Fellowship Address. In 1920 he presented a Great Mace to the American College from the Consulting Surgeons of the British Armies in memory of mutual work and good fellowship in the then recent war. At that time he delivered the first John B. Murphy Memorial Lecture. In this connexion I thought you may be interested in an encounter between Lord Moynihan and Dr. Murphy (our most renowned surgical orator) as related by Dr. J. M. T. Finney of Baltimore, the first President of our American College of Surgeons. Dr. Finney was describing a visit of the Society of Clinical Surgery to the British Isles in 1910. In his autobiography he states: "The final day was spent at the Clinic of Sir Berkeley Moynihan in Leeds. In addition to his wide reputation as a skilful surgeon, Sir Berkeley was noted for his ability as a speaker. I have never heard anyone who exhibited such facility in this respect or possessed such command of the English language. He always used the right word in the right place at the right time, and did it with ease and grace. He gave the Club a dinner one evening while we were there. As we knew that there would be oratorical fireworks after the dinner, we decided that John B. Murphy of Chicago, another Irishman, was best fitted to respond on our behalf.

"We were not disappointed in our expectations. After the dinner, Sir Berkeley in his most gracious manner welcomed us and proposed a toast to the President of the United States. Dr. Murphy arose to reply. He prided himself not a little on his ability as a talker, and since he had known what he would be up against on this occasion, he had prepared himself for it. We thought he acquitted himself pretty well. But when he had finished, Moynihan took his turn, and his speech was a perfect gem. Everybody was delighted with the pleasant evening except Murphy. He was very downcast. He knew that he had been beaten, and it was an unusual experience for him. I did my best to cheer him up, but it was no use. Finally I gave it up with the reminder that it was Irish pitted against Irish, but the trouble was that his opponent had red hair, while his was only black. That thought seemed to comfort him more than anything else."

Leeds has been to me a very cordial and warm city. An example of this cordiality and hospitality, which may seem trite to you but was very important to me, occurred when I arrived here two years ago in dire need of laundry service. The following letter speaks for itself. You can well imagine my gratitude.

(*From Hygienic and Weight Wash Laundries, Cecil Road, Armley, Leeds*)

9th May, 1952.

Dr. Blalock,
Room 220,
Queen's Hotel,
Leeds.

Dear Sir,

We are returning your laundry work and trust that you will find this satisfactory.

We are pleased to have had this opportunity of offering you this special four-hour service and, in the event of your visiting Leeds again, we shall be glad to serve you.

Yours faithfully,
for The Hygienic Laundry,
A. M. BUTLER, *General Manager.*

There are many reasons why I am grateful for the invitation to deliver this lecture. One is that it gave me the opportunity of attending this interesting

* Moynihan Lecture, delivered at Leeds on May 14, 1954, at the time of the meeting of the Association of Surgeons of Great Britain and Ireland and the Sectional Meeting of the American College of Surgeons.

and instructive meeting of the Association of Surgeons. Another is that it allowed me the pleasure of renewing my friendship with the Philip Allisons. The brilliant work reported by Mr. Allison yesterday gave me a great thrill. Still another reason is the fact that the first Leeds biennial Moynihan Lecture was delivered by Sir Gordon Gordon-Taylor, for whom I have the most profound admiration.

As has been stated, the title of this lecture is " The Expanding Scope of Cardiovascular Surgery ".

## GENERAL REMARKS

If one views the state of surgery from week to week or month to month, one is likely to think that no progress is taking place. On the other hand, if one compares the present with that existing several years ago, it is obvious that surgery is not static.

Before considering the developments that are responsible for the recent rapid advances, it should be mentioned that the progress in cardiovascular surgery has had favourable effects on other related fields. Anæsthesia has improved greatly in centres in which cardiac surgery is being performed, and there have been great advances in some radiological diagnostic methods. The surgical treatment of certain types of valvular heart disease has stimulated sharpening of diagnostic acumen and convinced the internist of the limitations of the stethoscope as a diagnostic tool. The point I wish to make is that the development of surgery of the heart and great vessels has exerted favourable effects on other fields and that the debt to related interests is not a unilateral one.

What are some of the reasons for the rapid recent progress in cardiovascular surgery? Many would reply that they have resulted mainly from improvements in anæsthesia, the development of antibiotics, and progress in the prevention and treatment of shock. This reply is only a partial answer. Some of the developments should have been apparent many years ago. For example, Souttar in 1925 dilated the mitral orifice of a patient with stenosis, considerable improvement resulting. Despite his pleas for additional patients, none was supplied by his colleagues. It is possible the greatest benefit which resulted from the discovery that the patient with the tetralogy of Fallot can be improved by operation was the demonstration that the sick cyanotic patient can withstand anæsthesia and operation. The results indicated that other lesions might respond favourably to operative treatment and that the mortality need not be prohibitive. Cardiologists became more surgically minded. Internists, surgeons, radiologists, and physiologists became more interested in diagnostic methods such as cardiac catheterization and angiocardiography. Whenever a successful method for treating a disorder is found, accuracy of diagnosis is increased. I repeat that the attitude of the cardiologists toward operative procedures has changed greatly and is responsible for much of the recent progress.

**Blood-vessel Grafts.**—Another example of readily available information which until recently was not appreciated, is that on blood-vessel grafts. Fifty odd years ago, Jaboulay, Carrel, and Guthrie reported the successful homotransplantation of arterial segments in animals. Carrel's arterial segments were preserved in Locke's solution and he thought that tissues must be alive if satisfactory transplantation is to be accomplished. However, in 1919 Guthrie reported the use of a formalin-fixed arterial graft which had been conducting blood successfully for twelve years. Despite the knowledge that the autotransplantation of arterial grafts, whether living or devitalized, could be performed successfully in the animal, it was only recently that clinical trials were made. The encouraging results are common knowledge. The difficulties of obtaining suitable grafts and the short life of such grafts preserved in nutrient media have prompted the development of other methods of preservation. The freeze-drying technique (lyophilization) is a very useful one in that the grafts can be kept indefinitely. How well the homografts will weather the turmoil of a long life remains to be determined. Current literature contains an increasing number of reports attesting to the usefulness of homografts for the surgical treatment of coarctation of the aorta, aortic aneurysms, repair of primary arterial damage, and replacement of blood-vessels involved in neoplastic disease. Thus a technique which was developed many years ago and which lay dormant has been revived and is contributing to the recent rapid advance in cardiovascular surgery. Current work on the bridging of arterial defects is centred mainly around the use of synthetic materials such as Vinyon ' N ' cloth, and the early results are amazingly good. The difficulties associated with the obtaining and preserving of homografts will be eliminated if the synthetics are good substitutes.

**New Instruments.**—There appears to me to be an inclination on the part of many persons interested in basic or fundamental research to sneer silently at efforts to develop better tools or gadgets. This attitude would seem somewhat out of order in the present mechanical age. I am reminded of this by the recent trouble experienced by Dr. Willis Potts in having accepted for publication his description of the multi-toothed ductus clamp, the design of which introduced a new principle in surgical instruments. After Dr. Potts prevailed upon a university press to publish the article, the manufacturer has been unable to meet the requests for this type instrument. The multi-toothed clamp, which is obtainable in variable sizes and shapes, allows one to hold tissues and blood-vessels securely without crushing them. Furthermore, the blade of the clamp is so thin that double clamping of a short structure such as a short patent ductus or an aortic-pulmonic defect still allows room for closure of the divided two ends.

Included among many other useful instruments are the Potts-Smith clamp for partial occlusion of the aorta, the Potts expanding knife and dilator for the treatment of pulmonary stenosis, the Bailey dilator for aortic stenosis, the Brock knives for mitral stenosis, the Hufnagel valve for aortic insufficiency, and the Gross rubber well for operations on auricular defects.

The point I wish to emphasize is that gadgets and tools have played an important part in recent developments in cardiovascular surgery. Given a sound, fundamental concept in surgical therapy, it

is much more apt to be executed successfully if suitable instruments are available.

**Surgical Technique.**—I hope the audience will forgive me for emphasizing a few points in surgical technique that are well known to most of you. These points apply in particular to cardiovascular surgery. The first and probably most important of these has to do with the value of good scissors in the exposure and isolation of large blood-vessels. The one used most often is the Metzenbaum type with slightly curved blades. The thin flat opposing surfaces at the tip allow the surgeon to see exactly what he is cutting. If the tissues surrounding the vessel are grasped with a slightly curved delicate clamp placed on in the direction of the long axis of the blood-vessel, one can cut very close to it without injuring it.

I would like to mention several other points in technique which are elementary but important. It is helpful in vascular surgery to have a clear, dry field. Frequent irrigation of the area with salt solution aids in accomplishing this and in preventing the tissues from becoming too dry. Pressure with a moistened sponge will rid the tissues of small hæmatomata. Another point in technique has to do with the control of brisk hæmorrhage that may follow the withdrawal of an instrument which is used for some intracardiac procedure. If one will place the gloved finger over the opening for several minutes the bleeding will be reduced and sutures can be placed more accurately. These are but a few of many simple manœuvres that are helpful.

**Hypothermia; Mechanical Heart Lung; Cross-circulation.**—I am so uncertain at the moment about the relative values of hypothermia, of the mechanical heart lung, and of cross-circulation as adjuvants in cardiac surgery that I will not dwell on the subject. Much work is being performed on hypothermia in Canada, in the British Isles, and in the United States as well as elsewhere. There are certain dangers associated with marked reductions in body temperature, but there is no doubt that hypothermia will permit a more prolonged interruption in the circulation, especially in the cyanotic patient. The mechanical heart lung for temporary replacement of the functions of the heart and lungs is theoretically the ideal, but still presents many problems. At the moment I am enthusiastic about the use of the cross-circulation in which the donor oxygenates the blood of the recipient as studied experimentally by Andreason and Watson of London. This excellent work was performed at the Buckston Browne Experimental Farm, in which Lord Moynihan had a deep interest. A pump which balances the arterial inflow and the venous return is an essential part of the procedure. Lillehei and Varco of Minneapolis recently used this method in operating on an infant of 20 lb. The father, the donor, weighed 175 lb. The right ventricle of the child was open for about thirty minutes and an interventricular defect was closed. This patient died of pneumonia, but two subsequent operations have been successful. In brief, the lungs and heart of one subject support life in a second whilst the latter is being subjected to an operative procedure on his excluded heart. This method, while not perfect, allows a longer operating time than is possible with hypothermia and eliminates many difficult biochemical and physical problems associated with the use of the artificial heart-lung machine. Further investigation of all of these important adjuvants is indicated.

**Exploratory Surgery.**—Exploratory surgery of the heart and great vessels has been added to that of exploration of other regions of the body as a diagnostic and therapeutic aid. Pressures in the various regions may be determined by inserting a needle connected to a recording manometer. This latter method is helpful in determining the site of pulmonic stenosis. Inspection and palpation of the heart will give information about the size and contour of the heart and about the location and time relationships of palpable thrills. As examples, aortic stenosis is usually accompanied by a systolic thrill in the ascending aorta, pulmonary valvular stenosis by a systolic thrill in the pulmonary artery, infundibular pulmonary stenosis by a diffuse systolic thrill over the base of the right ventricle, and mitral stenosis by a diastolic thrill over the apex of the left ventricle.

Palpation and inspection of the structures in the mediastinum may reveal patent ductus arteriosus, bifid aortic arch, coarctation of the aorta, anomalies of venous return, aortic aneurysms or other abnormalities. Digital examination of the interior of the heart may be performed through the left or right auricular appendages or the right ventricle. A variety of abnormal findings may be detected. Included among these are valvular stenosis, valvular insufficiency, intracardiac thrombi, tumours, and interauricular and interventricular septal defects. It seems clear that the indications for exploratory surgery of the heart will be extended further.

## SPECIFIC DISORDERS

I will consider now some of the specific cardiovascular lesions or disorders, dealing largely with recent contributions and work in progress. Since the treatment of congenital lesions preceded the recent upsurge in interest in the therapy of acquired lesions, the former will be taken up first.

**Patent Ductus Arteriosus.**—The patent ductus arteriosus problem was solved so well by Gross and his associates that little has been added. I would like to emphasize that the typical machinery murmur is dependent upon the gradient in pressure in the pulmonary and systemic arterial circulations and may be absent if pulmonary hypertension is present. It is very important to recognize and to treat the ductus accompanied by hypertension. The large short ductus should be divided and the two ends closed. Except for these, permanent closure can be produced by the use of multiple suture ligatures.

**Coarctation of the Aorta.**—Coarctation of the aorta can usually be diagnosed with ease and can be treated with satisfaction by resection and end-to-end anastomosis. The best contribution in therapy since Crafoord and Gross described this procedure in 1945 has been in the use of the aortic homograft by Gross and associates. We advise operation once the diagnosis is established in patients between the ages of 10 years and 25 years. Below the age of 8 or 10 years, operation is postponed unless evidence of heart damage is present. Above the age of

25 years operation is advised if the hypertension is of severe degree and/or symptoms are present. Angiocardiographic studies are rarely indicated in the pre-operative study if blood-vessel grafts are available for use in case the constriction is too long to permit an end-to-end anastomosis. It is my impression that end-to-end anastomosis is feasible in the vast majority of patients if the structures are properly mobilized and that the use of an aortic graft is rarely necessary. It is extremely important to obtain an aortic lumen of large size, but it need not be quite as large as the normal aorta. Given the choice between an aortic lumen that is slightly reduced in size without use of a graft and a somewhat larger lumen resulting from the employment of a homograft, I would choose the former because of the uncertainty that still exists regarding the ultimate fate of homotransplants. However, we do not hesitate to use an aortic graft if the constricted segment is too long to permit a satisfactory end-to-end anastomosis. Cardiologists should refer their patients for operation before marked aortic disease, including the formation of aneurysms, takes place.

**Tetralogy of Fallot.**—Turning our attention to a form of congenital heart disease which is usually accompanied by cyanosis, we will consider first the tetralogy of Fallot. It is important to distinguish between pulmonary stenosis as a part of this condition or some variant of it and the condition known as pure or valvular pulmonary stenosis. The venous blood which is pumped by the right ventricle may enter either the stenotic pulmonary opening or the overriding aorta. When the subject is at rest, there may be only a moderate right to left shunt and minimal cyanosis. With the increase in cardiac output accompanying exercise, the stenotic area does not allow much elevation of pulmonary blood-flow and the right to left shunt and the resulting cyanosis increase.

The operative procedures that have been developed for the treatment of the tetralogy of Fallot have as their objective the increase of pulmonary blood-flow. This may be accomplished by a shunting procedure or by a direct attack on the stenotic area itself as advocated by Brock. Since the blood in the aorta and its branches is not normally saturated with oxygen, and since the pressure in the systemic arteries is much higher than that in the pulmonary arteries, it is obvious that an anastomosis between the two will shunt blood to the lungs and will result in a decrease in the cyanosis and disability. The rationale of the direct attack on the stenotic area is even more easily apparent. The shunting or by-passing procedures can be used in all patients with the tetralogy of Fallot who have a pulmonary artery of sufficient size for an anastomosis. The direct attack on the stenotic area may be employed in patients with a moderate to large infundibular chamber and those with a valvular stenosis, and probably should not be attempted in those with a small infundibular chamber and those with pulmonary atresia. In our hands the direct attack on infundibular stenosis is accompanied by a higher mortality, and the results in the surviving patients have been no better than in those in whom an artificial ductus was created.

Taussig and Bauersfeld carried out a follow-up study on the first 1000 patients who were operated upon for pulmonary stenosis or atresia in the Johns Hopkins Hospital. Of those with a pre-operative diagnosis of tetralogy of Fallot, it was found that 15 per cent died while in the hospital, that 2 per cent died in the ensuing eight months, and that 78 per cent obtained a good result. During the seven-year period over which the study extended, there were only 22 cases of subacute bacterial endocarditis with 4 deaths. The report by Campbell and Deuchar, of London, of the results of 200 shunting procedures by Brock, Sellors, and Hill does not differ greatly from our experience. They state: "Most had Fallot's tetralogy, and here the results were excellent. Many were seriously ill, but only 8 per cent died and 75 per cent benefited greatly, so that they can walk a mile or more and lead lives that are almost normal without too much physical activity." Despite these good results, all of us should maintain an open mind regarding the possible advantages of the direct attack of Brock. Additional experience will probably delineate more clearly the place of each of these procedures, or, in fact, may show that both of them are outmoded by a better operation. For example, using hypothermia, Dr. H. W. Scott recently closed under direct vision an interventricular defect and enlarged the pulmonary outflow tract in a cyanotic infant with Fallot's tetralogy. The venous return to the heart was occluded for eight minutes. The results of further efforts will be awaited with interest.

**Valvular Pulmonic Stenosis.**—I wish to repeat that some patients with the tetralogy of Fallot have valvular rather than infundibular stenosis and that satisfactory results usually follow either a shunting procedure or a direct attack on the valve. Such is not the case in the treatment of pure or valvular pulmonic stenosis unaccompanied by an interventricular septal defect. In valvular pulmonic stenosis the blood in the systemic arteries may be normally saturated with oxygen, and hence the patient would not be benefited by the repeated passage of this arterial blood through the lungs as a result of a shunting procedure. It is, therefore, very important to differentiate between the tetralogy of Fallot and valvular pulmonic stenosis without an interventricular defect.

It is my impression that patients with valvular pulmonic stenosis should be operated upon before the pressure in the right ventricle becomes markedly elevated even though their disability is mild. As pointed out by Brock, Sellors, and others, the approach should be through the right ventricle and the stenotic valve should be incised and dilated. Several types of knives are available for this purpose, probably the best of which is the Potts type which can be opened after it is introduced into the right ventricle. If an error is being made in the present prevailing method of therapy, I think it is on the side of not making the opening large enough. Further experiences may show that part of the stenotic cusps should be removed; in fact, this has been done by several surgeons. For example, Swan recently reported operations on eight children under hypothermia, the procedure consisting of partial excision and wide incisions of the valve leaflets. It must be said, however, that the present prevailing

method of therapy of incision and dilatation is yielding remarkably good results with a low mortality-rate. Nevertheless, patients who have been operated upon should be followed carefully and the possibility that present therapy may not be adequate should be borne in mind.

**Transposition of the Great Vessels.**—Time will not permit an adequate discussion of transposition of the great vessels, a condition in which the aorta arises from the right ventricle and the pulmonary artery from the left ventricle, without an accompanying transposition of the great veins. We have operated upon over 90 patients with this condition and, although the majority of them have succumbed, some have survived and have shown definite improvement. The operative procedure that we have used in most of them consists of excising the septum between the two auricles. In addition in some of them an artificial ductus has been made. The best results have been obtained in those with an associated pulmonary stenosis and in those with the Taussig-Bing type of transposition. Further efforts to perfect methods for transposing the great veins in order to compensate for the transposition of the great arteries appear to be indicated.

**Auricular Septal Defects.**—Of the various problems in congenital cardiovascular surgery, that of the closure of interauricular defects has stimulated the greatest interest in recent months. It is a good example of the fact that surgical advances reach a given point and then the efforts in many laboratories and clinics are directed simultaneously towards the solution of the same problem. A defect in the interauricular septum is one of the more common congenital cardiac defects and frequently is an isolated one. Some of these produce no symptoms and are compatible with long life. Others, even though of moderate size, may result in a large left-to-right shunt and in progressive symptoms resulting in disability and heart failure.

Many believe that the best method advanced thus far for the closure of the larger defects is that of Gross in which a rubber well is sutured to the auricle and then the defect is closed by suturing plastic material to its edges, or in some cases simply by the use of interrupted sutures. It is possible that the best method is the Bjork and Crafoord modification of the procedure of Sondergaard and Husfeldt in which a suture grasping the auricular and ventricular septa is tied in a groove between the venæ cavæ and the pulmonary veins.

At any rate, the problem of the closure of interauricular defects is a mechanical one and will almost certainly be solved in a satisfactory manner.

**Ventricular Septal Defects.**—Ventricular septal defects vary greatly in position, in size, and in the symptoms, if any, associated with them. It is in patients with large high defects that symptoms are most apt to be present. Many efforts have been made to find a satisfactory method for closing these defects and some encouraging results are being obtained. I have already referred to the use of hypothermia and of the cross-circulation as aids in the closure of ventricular defects under direct vision.

Leaving the congenital field, I will comment now on some acquired lesions.

**Heart Wounds with Tamponade.**—Wounds of the heart accompanied by tamponade and hence a cessation of active bleeding can usually be treated satisfactorily by simple aspiration with a needle and syringe. Open operation should be performed if tamponade recurs after two or more aspirations.

**Constrictive Pericarditis.**—My ideas about constrictive pericarditis are in agreement with those that have been expressed in recent years by Sweet and Churchill and others. I refer to the evidence that the signs and symptoms in most patients are due to constriction of both the right and left ventricles and that both should be decorticated. Furthermore, I subscribe to the viewpoint that the best exposure is obtained through a long left anterolateral transpleural incision through which both sides of the heart can be decorticated. Some of my earlier results were poor owing to inadequate exposure through a parasternal incision.

**Mitral Stenosis.**—Efforts directed toward the treatment of mitral stenosis are of particular interest because they have extended over so many years. In 1902 Sir Lauder Brunton stated that mitral stenosis should be amenable to treatment by surgical means, and he raised the question whether the natural opening should be elongated or the valves should be cut transversely. Brunton was criticized severely for advancing a hypothesis without adequate experimental or clinical support. Samways chided him for his remarks on the specific area of attack by stating, " The question which Sir Lauder Brunton raises whether to elongate the natural opening or cut the valves transversely is a problem somewhat similar to which foot should be drawn down in podalic version." All who are familiar with the present attack upon the commissure regions will agree that Brunton's thinking was well in advance of the time. Most are familiar with the efforts in the 1920s of Cutler and associates to divide the mitral valve through a transventricular approach and that of Graham and Allen to approach the diseased mitral valve through the left auricular appendage. It is not fully appreciated that Souttar in 1925 inserted an index finger through the left atrial appendage and successfully dilated the mitral orifice and possibly split the commissures in a patient with mitral stenosis. The procedure was largely ignored until the late 1940s, when Smithy, Bailey, Harken, Brock, and others revived interest in it.

Attacks of rheumatic fever may cause varying degrees of disease of the valves and their attachments. Despite these variations, one is impressed by the fact that the diameters of the mitral orifice in the majority of patients operated upon for mitral stenosis are approximately 10 by 5 mm. The differences between patients with so-called severe and those with mild stenosis are due more to the physio-pathological alterations that occur as a result of the stenosis than to significant variations in the size of the mitral opening.

The operative procedure that we use is the one that is more or less standard. In more than 80 per cent of cases the commissures can be fractured or torn with the finger. In others they are cut with a knife or torn with the DuBost dilator. The operation is a sound one.

**Mitral Insufficiency.**—Whereas progress in the treatment of mitral stenosis has been truly dramatic, that in the treatment of mitral insufficiency has been disappointing. In the severe types the entire mitral ring is dilated, the cusps are shortened and the problem of preventing regurgitation is a difficult if not impossible one. A number of methods have been tried experimentally and clinically. Most of these have consisted of placing a baffle of pericardium or some plastic material beneath the mitral orifice with the hope that it will fall away from the opening in ventricular filling and will prevent regurgitation in systole. The most encouraging experimental results which Dr. Johns and I have obtained have resulted from the use of a plastic sponge which is placed just beneath the mitral orifice and anchored in the region of the papillary muscles. Harken uses a solid spindle baffle anchored in a similar manner. I think the plastic sponge is more apt to remain in place than is the solid baffle.

Another method is that of Bailey in which he attempts to reduce the size of the opening by passing suture ligatures of pericardium through the valve leaflets. I doubt the soundness of this procedure. Most workers in this field will undoubtedly agree that the surgery of mitral insufficiency is still in the experimental stage.

**Aortic Stenosis.**—Fortunately definite progress has been made in the treatment of aortic stenosis. Patients with this condition may do well for years but are apt to fail very rapidly after an advanced stage has been reached. Most of the successful operations have been performed by an approach through the left ventricle. Probably the best instrument devised thus far for tearing or fracturing the stenotic valve is that of Bailey and associates. Although the treatment of aortic stenosis is not in as satisfactory a state as the therapy of mitral stenosis, it is pleasing to say that real progress has been made.

**Aortic Insufficiency.**—The therapeutic problem presented by aortic insufficiency is indeed a difficult one. Attempts to place a baffle in the region of the insufficient valve have not been encouraging. The best results have been obtained by Hufnagel following his development of a valve made of lucite which contains a small ball shuttle inside a valve chamber. This valve is inserted in the upper part of the descending aorta. A technique has not been developed for placing the valve in the ascending aorta, and in fact this position might be incompatible with adequate coronary flow during ventricular diastole. Following insertion of the valve in the descending aorta, signs of regurgitation persist in the upper part of the body but are absent in the trunk and lower extremities. Hufnagel has operated upon about 60 patients with an early mortality of about 25 per cent and improvement in many of the survivors. Despite the encouraging results, the therapy of aortic insufficiency is far from solved.

The same remark applies to the treatment of coronary insufficiency, one of the most important problems in medicine. I will not attempt to evaluate the effectiveness of the various surgical procedures that are being used.

**Aortic Aneurysms.**—The last subject to be commented upon is aortic aneurysms. Recent advances in therapy have been important and spectacular. These methods include: Ligation; Wiring; Fibrogenic material; Endo-aneurysmorrhaphy; Excision.

The two predominating types of aortic aneurysms are saccular and fusiform and the two leading aetiological agents are syphilis and arteriosclerosis. By way of differential diagnosis it may be stated in general that syphilitic aneurysms are saccular, are located above the renals, they usually occur in patients under 55 years of age, pain is usually severe, there is often erosion of bone, and the prognosis without surgical treatment is poor. On the other hand, arteriosclerotic aneurysms are fusiform, are located usually below the renal arteries, the patients are usually over 60 years of age, pain is mild, bone erosion is rare, and the prognosis is variable. Comments on therapy will be limited to the excisional method. Leaders in this field include DuBost, DeBakey, and Cooley, and Bahnson. In brief, the treatment of saccular aneurysms of the thoracic aorta consists of exposure and division and closure of the neck of the sac and removal of the sac. The treatment of fusiform aneurysms of the abdominal aorta consists of excision of the involved segment of aorta and replacement with a homotransplant of aorta or a plastic tube. The results that are being obtained are very gratifying.

In concluding, I repeat that there has been rapid progress in recent years in cardiovascular surgery. Among the many factors responsible for this progress are advances in related fields such as anæsthesiology, antibiotic therapy, and shock therapy; an appreciation of the value of work performed years ago, such as that on blood-vessel grafts; improvements in surgical technique, including the development of ingenious procedures and appropriate instruments with which to perform them; advances in diagnostic methods; and a better understanding of the physiopathology of many cardiovascular disorders. Many unsolved problems remain as a challenge to the medical profession.

# HIATUS HERNIA*

## A REVIEW OF SOME CONTROVERSIAL POINTS

By N. R. BARRETT, London

Certain steps can be traced in the evolution of any branch of surgery; they are well shown in hiatus hernia. Until P. R. Allison, with the help of Professor Johnstone of Leeds, described a scheme to cover the pathology, diagnosis, and treatment of 'reflux œsophagitis' there was no rational basis for the operations done to alleviate the majority of these patients. Up till a few years ago the symptoms of hiatus hernia were ascribed to other lesions, and the first operations were based upon the knowledge applicable to the common types of superficial hernia. There followed a period in which surgeons, realizing some of the special problems involved, debated the methods of access and the details of surgical techniques: they argued the relative merits of the abdominal *vis-à-vis* the thoracic approach. We now find ourselves in the more mature position of pondering the rationale of what we are trying to achieve and the results of our early efforts. It is against this background that I wish to discuss certain controversial issues.

## THE ANATOMY OF HIATUS HERNIA

A source of confusion has been the number of slightly different varieties of hiatus hernia which have been described. To my mind only those should be retained which require modifications of treatment because of their special anatomy or pathology. I believe that four groups can be so separated with advantage.

**1. Congenital Short Œsophagus.**—The features which mark out a congenital short œsophagus anatomically are these: it is not a hernia, but is relevant to any discussion about hiatus hernia because it may cause symptoms which are comparable. The gullet which traverses the mediastinum from the pharynx to the abdomen has the external appearance of a normal œsophagus: but the lower end is lined by columnar gastric epithelium to a lesser or greater degree. The most marked case of this kind which I have seen occurred in an infant, who died shortly after birth, and at autopsy it was found that gastric mucosa began 1 in. below the cricoid cartilage and extended in an unbroken sheet to the duodenum.

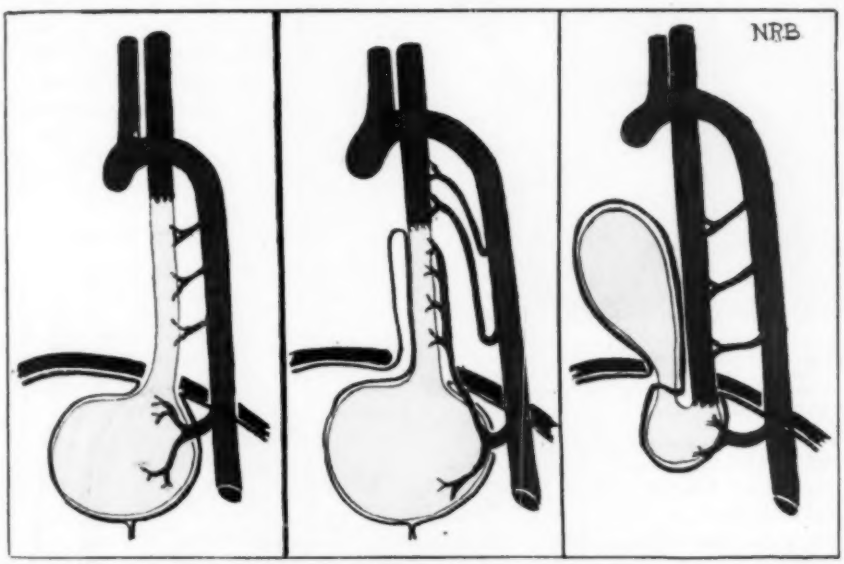



Fig. 254.—Diagrams to show the difference between congenital short œsophagus (on the left), sliding hiatal hernia (in the middle), and para-œsophageal hernia (on the right). *Blue*, œsophagus; *Yellow*, stomach; *Red*, aorta; *Black*, diaphragm; *Green*, peritoneum. In each case the parts are depicted from the left lateral view. The aortic arch and subclavian artery are suggested: the œsophageal branches and the left gastric artery are also drawn.

A clear difference has not been made between true congenital anomalies of this type, which are rare, and sliding hiatus hernia discovered at or shortly after birth (*Fig.* 254). The term 'congenital short œsophagus' should be reserved for the former, in which the œsophago-gastric junction has never occupied a position below the diaphragm. The anatomy of most sliding hiatal herniæ in infants indicates that they are not developmental anomalies but are acquired.

A second confusion has arisen over the nomenclature of the parts, and this matters if one man is to know what another is talking about. It concerns the name to be given to that segment of the gullet which lies below the junction of the squamous and columnar epithelia in these cases. Everybody agrees that the upper part lined by squamous epithelium

* These remarks are the basis of a paper read to The Association of Surgeons of Great Britain and Ireland at their Summer Meeting at Harrogate, 1954.

should be called ' œsophagus '. I have regarded the lower part as a direct extension of the ' stomach ' because the pathological abnormalities to which it is heir are due to its columnar epithelium and they resemble gastric lesions. Allison and Johnstone (1953) call it ' œsophagus lined with gastric mucous membrane '. Let us be clear that neither of us is talking about islands of ectopic gastric mucosa which

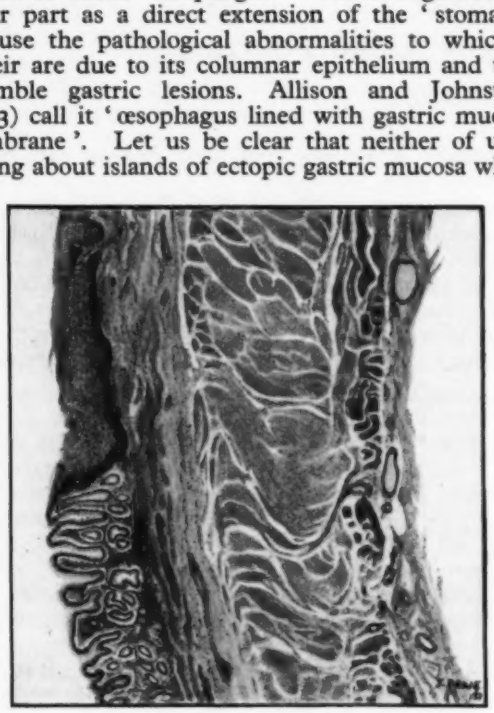


FIG. 255.—Painting made from a slide cut through the œsophagogastric junction. Its purpose is to show that there is no difference between the muscle of the œsophagus and that of the stomach at the cardia.

are frequently found at the upper end of the normal œsophagus. Allison stated his objections to calling it ' stomach ', as follows :—

1. It has no peritoneal coat. (But neither has the bare area of the stomach.)

2. The musculature is that of the normal œsophagus. (I cannot discern any essential difference in the histological appearances of the musculature of the upper part of the stomach and the lower part of the œsophagus—*Fig.* 255.)

3. There may be islands of squamous epithelium within it, and there are no oxyntic cells in the mucosa. (These observations may be true, but are irrelevant to the argument because there is no doubt that gastric ulcers and gastric carcinoma can develop in the part of the gullet under consideration.)

Whatever this reach of the gullet be called we must remember two points about it. A segment of gullet which looks like œsophagus but functions as stomach can occur above a normal diaphragm and œsophageal hiatus ; and, upon rare occasion, the anatomy may be even further complicated—as Allison has shown—by a sliding hiatal hernia below the level of the ' gastric lined œsophagus '.

Congenital short œsophagus cannot be diagnosed with certainty before the gullet is examined at thoracotomy. Its presence may be suspected at endoscopy if the gastric epithelium reaches an unduly high point in the gullet ; but the diagnosis of congenital short œsophagus can only be confirmed by observing that, in spite of the gastric lining of the gullet, there is no peritoneal sac in the mediastinum, and the anatomy of the left gastric artery is normal ; the mediastinal part of the stomach is supplied by segmental branches from the aorta. That is, the gullet, lined by gastric epithelium, is not supplied by the left gastric artery except in the vicinity of the œsophageal hiatus. The surgical import of these facts is that although the patient may have symptoms comparable to those produced by a sliding hiatal hernia, the operation which cures the latter cannot be done in some cases because the mediastinal part of the stomach cannot be elongated so that the cardia lies in the abdomen. In minor cases the diaphragm can be raised above the cardia if the surgeon believes that this might cure the symptoms.

Congenital short œsophagus lays the patient open to the ills of ' reflux œsophagitis '. My experience in this matter corresponds with that of Franklin, who has stated that the higher in the mediastinum the œsophago-gastric junction lies the less is the risk of digestion of the squamous mucosa, and it is chiefly in the minor degrees of congenital short œsophagus that œsophagitis occurs. The majority of the specimens I have examined have come from elderly patients who have died as a result of a massive

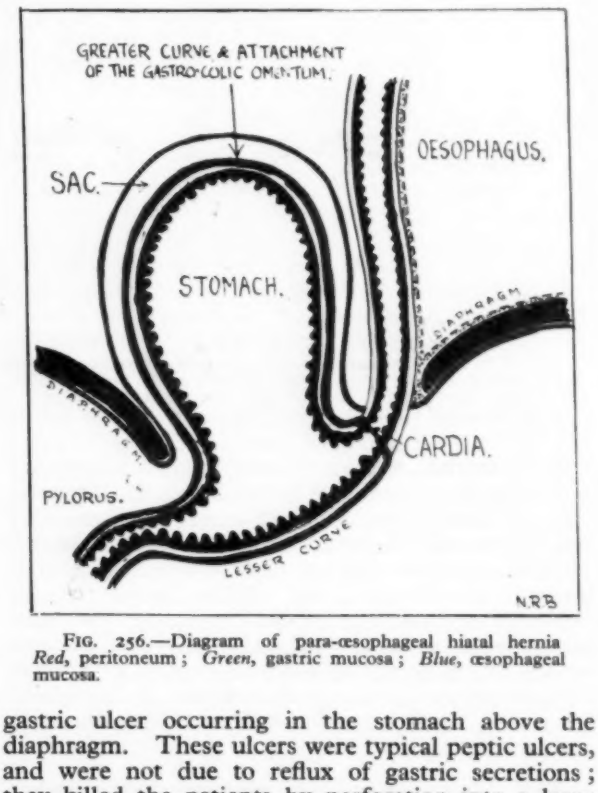



FIG. 256.—Diagram of para-œsophageal hiatal hernia *Red*, peritoneum ; *Green*, gastric mucosa ; *Blue*, œsophageal mucosa.

gastric ulcer occurring in the stomach above the diaphragm. These ulcers were typical peptic ulcers, and were not due to reflux of gastric secretions ; they killed the patients by perforation into a large vessel, such as the aorta or the pulmonary artery, or by perforating into the pericardium or the mediastinum.

**2. Para-œsophageal Hernia** (*Fig.* 256).—I suggest that para-œsophageal hernia is a true hernia in which parts of the abdominal viscera ascend into a *preformed peritoneal sac* lying in the mediastinum.

The most likely explanation of the presence of the sac is persistence of the *pneumato-enteric recess* on the right side of the gullet. Hamilton, Boyd, and

Mossman (1946) described this recess in these terms: "At about the 4-mm. stage, before the stomach has undergone rotation, small pocket-like excavations, right and left pneumato-enteric recesses, appear on each side of the dorsal mesogastrium. The left one is transitory and soon disappears, but the right one extends progressively into the mesentery not only transversely posterior to the stomach, but also cranially, on the right side of the œsophagus and posterior to the right lobe of the developing liver, toward the right lung bud. Eventually this recess forms a large irregular space with a narrow opening into the peritoneal cavity. With the development of the dorsal portion of the diaphragm and the associated closure of the pleuro-peritoneal canals the upper portion of the cranial extension of the right pneumato-enteric recess becomes separated from the more caudal portion, the primitive lesser sac, and forms a small closed supradiaphragmatic mesothelial cavity, *the infracardiac bursa*." (*Fig.* 257.)

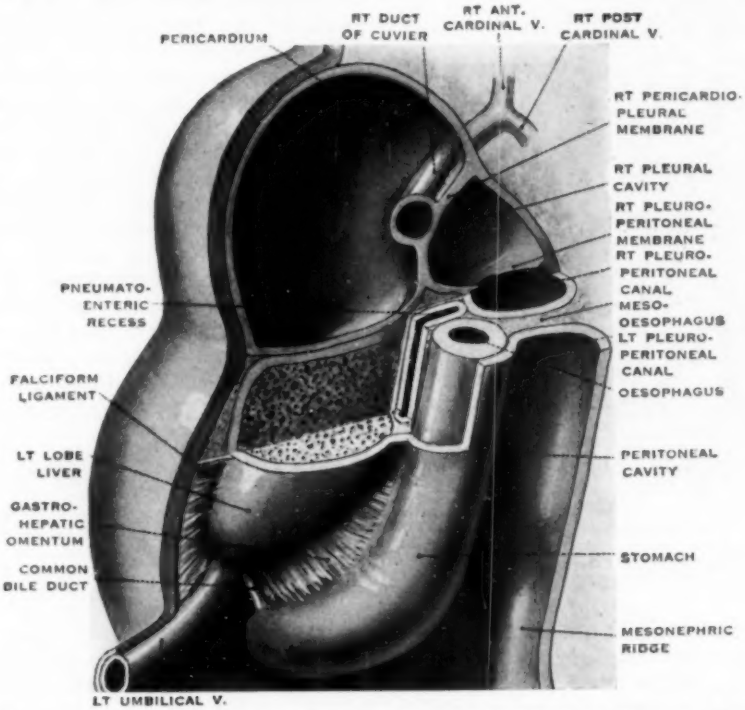



FIG. 257.—This photograph is taken from Hamilton, Boyd, and Mossman's book (2nd. ed., *Fig.* 222). It represents the anatomy of the cavities in the upper abdomen and the thorax of a 17-mm. human embryo, and shows the position of the pneumato-enteric recess.

I believe that some of the cysts which have been found on the right side of the œsophagus below the hilum of the lung, and which are not lined by epithelium, may be due to persistence of the infra-cardiac bursa. In which case they would be comparable to hydroceles of inguinal hernial sacs.

The way in which a para-œsophageal hernia grows is difficult to be sure about, because the patients have large defects when symptoms first develop, and one does not get the chance of watching the formative stages. The point at issue is whether the hernia passes through the œsophageal hiatus itself, or whether it is parahiatal as well as para-œsophageal. In making the latter suggestion there is no implication that the right pleuro-peritoneal canal has persisted. A hernia through the pleuroperitoneal canal passes through a defect in the diaphragm which lies immediately in front of the kidney and no sac exists; the viscera enter freely into the pleural cavity. By contrast a para-œsophageal hernia invades the posterior mediastinum. The descriptions which surgeons have given of their operative findings are at variance in the case of para-œsophageal hernia. Some have described a band of muscle or tendon (presumably a part of the right crus) lying between the œsophagus on the left and the hernia sac on the right: others have found no evidence of such a remnant. Which of these be the truth matters little in practice because by the time the patient comes to operation, the strand of tissue representing the remnant of the right crus is tenuous, if indeed it is present at all, and in consequence it is of no importance in the technique of repair. But if, as I believe, the hernia passes into a preformed mediastinal sac, that sac does not pass through the hiatus itself and, at the beginning, the remnant of the crus may be a factor in holding the cardia in the normal place, and so in determining the anatomy of the lesion. If the whole recess remains patent, the patient develops a para-œsophageal hernia inevitably.

The anatomical points about para-œsophageal hernia are these. The œsophagus is normal in length and anatomy. The cardia lies in its proper place and the left gastric artery tethers it effectively to the posterior abdominal wall. The lesser curve of the stomach is held between its two usual fixed points—namely, the cardia and the pylorus; and thus the greater curve of the stomach swings on the cardio-pyloric axis to occupy the top of the hernial sac. The gastrocolic omentum travels into the sac with the

stomach and lies in the front. It is rare for any viscus, apart from the stomach, to occupy the sac; but the colon may be drawn up as well, and Harrington has described one case in which he found only the colon. The sac is always complete; the hernia is not '*en glissade*'. The neck in most cases is large and adhesions are apt to form between the inside of the sac and the omentum it contains, and,

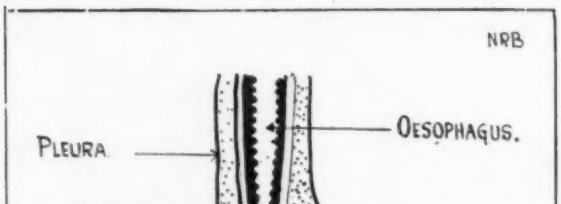



FIG. 258.—Diagram of sliding hiatal hernia. *Red*, peritoneum; *Green*, gastric mucosa; *Blue*, œsophageal mucosa.

for this reason the contents cannot always be reduced by traction from below the diaphragm.

The symptoms from which these patients suffer are various, and, upon occasion, a large hernia may be found at autopsy which has caused no troubles in life. The symptoms may be due to any, or all, of these four reasons:—

1. The hernia may be so large that it acts as a space-occupying mass behind the heart which may be displaced or rotated upon its base. Such patients complain of pains of cardiac type, amongst which angina pectoris can be closely simulated. Various arrhythmias occur.

2. When a large hernia gets distended by accumulation of gas in the herniated stomach the œsophagus, passing downwards to the abdomen over the surface of the sac, can be temporarily obstructed. Such a one complains of intermittent dysphagia.

3. The sac, and the omentum inside it, can cause obstruction or strangulation; this is rare.

4. The hernia may bleed causing anæmia, or a typical gastric ulcer may occur. These ulcers are often difficult to diagnose pre-operatively because they are within the sac and behind the heart. In several of my patients they have been responsible for most serious hæmorrhage, and perforation is not unknown. They are generally situated on the anterior surface of the stomach which now faces backwards.

Some of these patients can be treated conservatively if symptoms are mild and if there is nothing to hint at gastric ulceration. The basis of surgical management is to reduce the hernia, to repair the defect in the diaphragm by narrowing the œsophageal hiatus with stitches placed between the aorta and the œsophagus, and to fix the stomach below the hiatus.

**3. Sliding Hiatal Hernia** (*Figs.* 258, 259).—In my series this variety is about ten times more common than all the others put together. The hernia is small and '*en glissade*'; it is one in which the cardia and adjacent parts of the greater and lesser curvatures slide up into the mediastinum, carrying a small sac of peritoneum applied to the left side of the stomach. The right side of the hernia includes the bare area of the stomach and is devoid of peritoneum. The sac is always empty and its upper margin marks the junction of the squamous and columnar epithelium inside the lumen. The branches of the left gastric artery, which normally supply these parts, pass up into the mediastinum with the displaced stomach.

If we are to treat this condition successfully we should have some ideas as to why it matters and why it happens.

There are two groups of symptoms, which may occur separately or coexist, which bring these patients to a surgeon. The minority complain of pain or intermittent dysphagia, and at œsophagoscopy no evidence of œsophagitis is found. The majority come

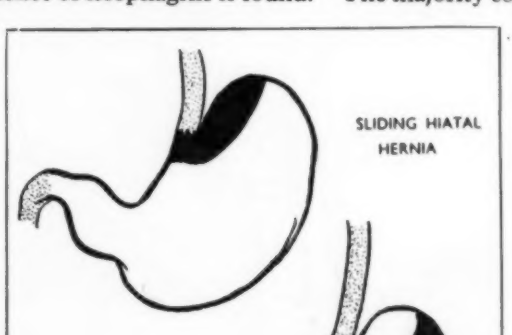



FIG. 259.—Diagram to illustrate the different areas of stomach involved in sliding hiatal and para-œsophageal herniæ. The black areas are herniated, the white areas remain in their normal position.

because reflux of gastric contents into the gullet is causing digestion of the mucosa—that is, 'reflux œsophagitis'.

It is not clear to me why all people do not develop a sliding hiatus hernia. The question is what allows the cardia to slide excessively in some people and not in others, and what prevents it returning to its normal position in those who have a persistent simple hernia. The explanations which came first to mind are not correct. It was thought that the stomach was dragged into the mediastinum by contraction of fibrous tissue in the wall of the œsophagus. But the hernia precedes and causes the œsophagitis and not the reverse.

It was also thought that the stomach might be sucked into the mediastinum because, during inspiration, the mediastinal pressure is lower than that in the abdomen. This idea was supported by measurements of the relative pressures in the œsophagus and in the stomach during respiration; by the fact that the diaphragm moves paradoxically after paralysis of the phrenic nerve, and because it was known that in traumatic diaphragmatic hernia, when the dome of the muscle has been punctured, omentum immediately insinuates itself through the breach. But the aetiology of sliding hiatal hernia seems to be little, if at all, concerned with suction, and the only explanations of this which I can suggest are that the œsophageal hiatus lies upon the downward curve of the diaphragm and faces the aorta and the vertebral column. If this be relevant one might argue that an aperture in this position is not subject to the piston action of the descending diaphragm, as one placed on the dome. And if this be true it would be an added reason for not doing operations which bring the œsophagus through an artificial hiatus in the front of the left diaphragm.

Sliding hiatal hernia is more prone to result from increases in abdominal pressure than from decreases in thoracic pressure (such as occur with atelectasis) and conservative treatment takes cognizance of this by reducing weight pre-operatively and by treating flatulence and its causes. Allison has said that if you can persuade a woman who wears corsets to remove them it will often be unnecessary to operate on her hernia—unfortunately we have no data from the Victorian era to support or disprove this.

A second factor which, to my mind, is decisive in whether a person develops a sliding hiatal hernia or not, is *the anatomy of the left gastric artery*. Many years ago Moynihan described this vessel as the anchor of the stomach because, in doing a partial gastrectomy, he found that the lesser curve could not be freely brought forward until the artery and its mesentery had been cut. I believe that in normal people the left gastric artery and its mesentery holds the cardia in its usual position and that if these structures are lax there is nothing to stop the cardia sliding into the mediastinum particularly if the abdominal pressure is increased. Sliding hernias are seldom large because there is a limit to the stretch in this vessel and its mesentery. It has been objected that if this idea were true a sliding hernia would form whenever a partial gastrectomy has been done. I believe this reasoning overlooks the fact that, in doing a partial gastrectomy, the greater part of the lesser curve of the stomach is taken away and the cardia becomes anchored to the pylorus and fixed by the post-operative scarring in the remains of the lesser omentum.

I now come to the role of the *œsophageal hiatus* in the development of a sliding hernia. If this hiatus is importantly linked with the prevention of a hernia under normal conditions, or even with the control of reflux from the normal stomach, then the surgeon who repairs such a hernia must aim at re-establishing the functions of the hiatus which have been lost.

The œsophageal hiatus is a foramen in the fibres of the right crus as they pass towards the dome of the left diaphragm. I believe that this foramen is so devised that it allows the œsophagus to pass through the diaphragm without impingeing upon the functions of the œsophagus; that it is not a factor concerned in preventing reflux, and that its repair is not the cardinal point in curing œsophagitis. (*Fig.* 260.)

The phrase '*the diaphragmatic pinchcock*' was devised by surgeons who introduced a finger into the lower œsophagus from the stomach at laparotomy

FIG. 260.—This painting was made from a specimen removed soon after birth, at autopsy, from an infant whose diaphragm was anatomically normal. The specimen is viewed from below and the œsophageal hiatus can be seen to lie in the right crus.

and felt the fibres of the diaphragm nipping the finger on inspiration. It was confirmed by radiologists, who found that, at the height of inspiration, a barium swallow was temporarily held up at the level of the hiatus. It has been given new importance in recent times because it has been compared in action by Allison to the pubo rectalis sphincter. For these reasons the œsophageal hiatus and the right crus were supposed to protect the normal person against reflux and to be a safeguard against sliding hiatal hernia. Indeed Belsey (1954) stated that reconstruction of an adequate sphincter—a function which he belived to be chiefly vested in the right crus—was the basis of surgical treatment. He says: "To assume that mere replacement of the stomach below the diaphragm is sufficient indicates a complete lack of appreciation of the control exercised by the normal right crus of the diaphragm on the lower œsophagus . . ." Some confusion has crept into these discussions because no clear distinction has been set between the reasons for repairing the crus, if it is found at operation to be lax, and the actual manœuvre which prevents reflux after operation. I believe that the crus must often be repaired at operation in the hope that it will help to prevent a recurrence of the sliding hernia. Repairing the crus and the hiatus and leaving the hernia in place has no effect whatever on reflux of gastric contents from the stomach into the œsophagus. This is achieved only

by reconstituting the œsophago-gastric angle, and is not influenced by the crus or the œsophageal hiatus.

In the early days of recognition of hiatal hernia it was customary for some surgeons, at laparotomy, to pass several fingers through the hiatus and, if it felt lax, to say that a hernia was present and to advise repair. We know now that the size of the normal aperture in the right crus is variable, and if the matter be studied at post-mortems it becomes apparent that a hole which is larger than normal does not predispose to a hernia in most cases. Moreover I have yet to satisfy myself that when a sliding hiatal hernia is present the hiatus is unduly large, and I do not know the size of the normal aperture.

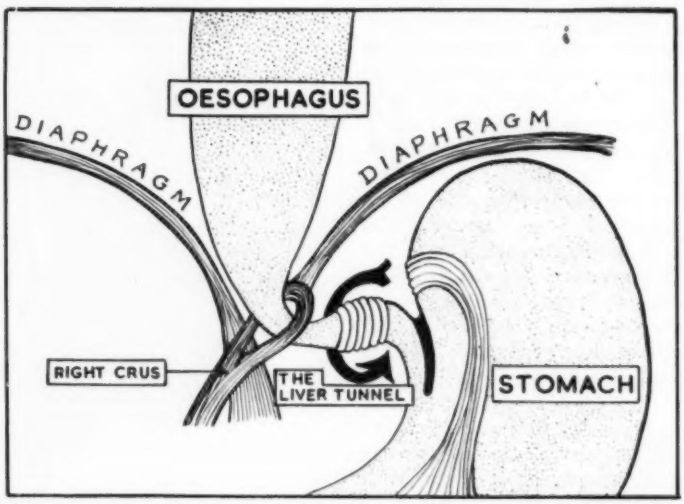



FIG. 261.—A diagram to show some of the 'mechanisms' which have been postulated to explain the 'cardiac sphincter'. The diaphragmatic pinchcock, the liver tunnel, the acute angle between the œsophagus above and below the hiatus, the supposed presence of special circular muscle-fibres in the lower œsophagus, the muscle sling in the stomach wall, and the œsophago-gastric angle.

In a recent important paper concerning the mechanisms of swallowing and reflux in normal œsophagus and cardia, Dornhorst, Harrison, and Pierce (1954) say this: "There has been some controversy over the part played by the diaphragm: the increased column of barium supported by the œsophagus during inspiration has been regarded as evidence of diaphragmatic constriction. Both our direct and indirect evidence is against this notion, which we think to be based on ignorance of the pressure changes involved and a misconception of the respective roles of gravity and of propulsive waves in the swallowing of liquids in the upright position." These authors also state that the crus never completely closes the œsophagus by pressure from without during deep inspiration. They do not deny that factors outside the œsophagus may indirectly modify competence of the cardia, but they emphasize that in the normal subject the essential mechanism lies in the œsophagus itself at the œsophago-gastric junction and not at the œsophageal hiatus of the diaphragm.

A second factor in the anatomy of the hiatus upon which stress has been laid is the *phreno-œsophageal ligaments*. These strands of tissue, which can be dissected out with the eye of faith, pass from the under-surface of the diaphragm, up through the hiatus, to be inserted into the musculature of the lower œsophagus. It has been claimed that they have given way in sliding hiatal hernia and that to prevent recurrence after reduction some form of surgical reconstruction is necessary. I have never repaired these ligaments and do not consider it necessary to dissect them out at operation: they can be ignored. In the normal body it is noticeable how the œsophagus passes through the hiatus with the minimum of fixation or tethering to the margins of the hole. For these reasons I do not believe that the fault in hiatal hernia lies in the anatomy of the phreno-œsophageal ligaments. A sliding hiatal hernia allows reflux of gastric contents into the œsophagus, and this brings us to a discussion of how the normal '*cardiac sphincter*' prevents reflux.

My colleagues (Dornhorst and others) at St. Thomas's Hospital and I believe that in a normal subject a barrier against reflux exists in the form of a flap valve of mucous membrane. (*Fig.* 261.) This valve is situated at the exact point of junction of the stomach with the œsophagus. It presents little or no obstruction to the downward flow of œsophageal contents, but is resolutely resistant to any reflux of gastric contents. It works by pouting of the gastric mucous membrane at the lower part of the œsophagus, and pressure changes recorded above and below the valve suggest that it operates over a distance of not more than 5 mm. The valve depends for its efficacy on the normality of the muscularis mucosa which moves the mucous membrane, and causes it to pout into the orifice. Although there is no muscle sphincter the barrier against reflux is extremely efficient. If at laparotomy a thoracoscope be inserted into the stomach, the cardia is so effectively closed that I have found it difficult to locate the orifice; and if a patient who has swallowed barium into the stomach is placed in the head-down position the cardia cannot be discerned as a dimple on the lesser curve in most people. Finally O'Mullane (1954) showed that the cardia is not made incompetent by total somatic paralysis under anæsthesia.

The foregoing remarks apply to competence of the cardia in a normal subject. When we consider the question of competence in patients suffering from simple hernia another factor is added, because the reflux which occurs when the hernia is present

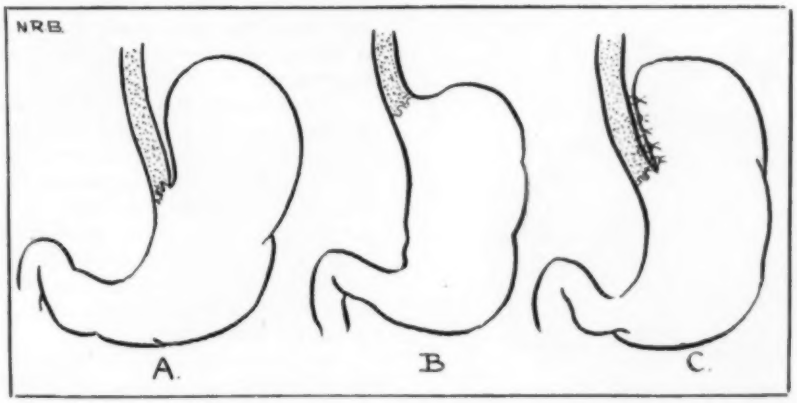



FIG. 262.—Diagram to illustrate the point that the normal stomach (A) has a considerable part of the greater curvature above the cardia, and reflux does not occur if the œsophago-gastric junction is low (B) the cardia becomes incompetent although a hernia is not present because the junction is high. (C) is the same as (B), but the top of the greater curve has been sewn to the œsophagus.

is straightway prevented by replacing the cardia in its normal position below the diaphragm. Allison stated that the angle at which the œsophagus actually entered the stomach was important in this connexion. He showed that if one took a stomach and œsophagus, removed from the body, and arranged the parts on the post-mortem table in their usual mutual relations, water pumped in through the pylorus was held at the cardia. If the parts were laid out in the form of a bell, with the œsophagus as a handle, the cardia became incompetent. Savage, at St. Thomas's Hospital, has recently shown that the stomach of a normal dog cannot be emptied by way of the œsophagus as long as the parts lie in the usual positions in the abdomen, but that the cardia becomes incompetent if the fundus is resected. I have found in the human subject that the cardia becomes incompetent as soon as the fundus of the stomach is depressed manually : and it seems to me that forcible depression of the diaphragm is the factor which allows a patient whose cardiac valve is normal to vomit.

In a recent communication to Brown's Club, Lortat-Jacob, of Paris, postulated that the cardiac valve may allow reflux of gastric contents if it so happens that the œsophagus opens into the stomach in an abnormally high position (*Fig.* 262). Such patients have no evidence of a sliding hiatal hernia at operation, or by any methods of investigation ; nevertheless they complain of symptoms due to œsophagitis, and are generally treated conservatively or by a psychiatrist without relief. He has cured such cases by sewing the top of the greater curvature to the side of the lower œsophagus in the abdomen, thus re-establishing the normal relations of these two structures to each other.

I believe that apart from the normal position of the lower œsophagus and the fundus of the stomach, which is maintained by the anatomy of the liver tunnel and the dome of the left diaphragm, another mechanism helps to keep the competence of the cardia—namely, the sling of muscle-fibres which lie immediately beneath the mucous membrane of the stomach, and which pass from the lesser curve posteriorly, around the œsophago-gastric junction and back on to the front of the stomach (*Fig.* 263).

By their contraction these fibres not only produce the 'gastric pathway', but accentuate the angle between the greater curve and the œsophagus : and

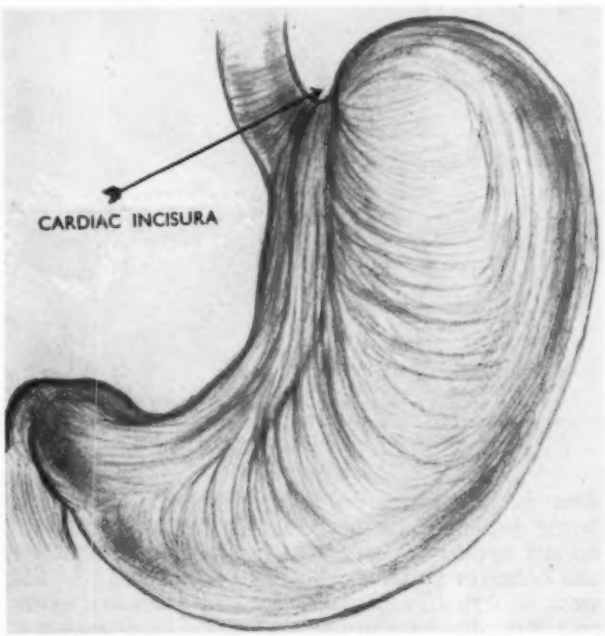



FIG. 263.—This is a drawing made from a freshly dissected human stomach. *Note* : The stomach was first turned inside out, and the mucosa was then removed. The muscle-fibres shown are those situated immediately deep to the mucous membrane. The purpose of the dissecton is to demonstrate the fibres which encircle the cardiac incisura and which could act as a sling as described in the text.

I have suggested that one reason why the cardia remains competent after Heller's operation is that this sling is left intact.

Wangensteen and his colleagues have shown the rapidly harmful effects of placing gastric contents in the œsophagus of an experimental animal. In man

this digestion may be intermittent or continuous: it may heal or progress; but whilst it operates it results in spasm, pain, bleeding, and ultimately in stricture and fixation of the œsophagus. The severity of the symptoms does not always tally with the extent of the œsophagitis; and, in particular,

FIG. 264.—Chronic fibrous stricture in lower end of œsophagus causing obstruction. Stricture is characteristic of those occurring as a result of long-standing digestion of œsophageal mucosa induced by incompetence of the cardia. The gullet below the stricture is stomach, and it lay in a hiatal hernia.

pain is not proportional to visible inflammation. Some patients who have œsophagitis at endoscopy do not appear to have acid reflux, and œsophagitis can occur in patients who have achlorhydria. The work of Aylwin (1953) has focused attention on the role of acid pepsin in the production of digestion of the lower gullet, and whilst one would not disagree with his observations, I believe that acid pepsin is not the only nigger in the woodpile. Any surgeon who has experience of upper abdominal fistulæ will know that the duodenal contents can cause just as serious destruction of the skin of the abdominal wall as the acid secretions of the stomach. I have, on one occasion, anastomosed the lower œsophagus to the first part of the duodenum after a total gastrectomy, and the patient developed severe œsophagitis some months later. For these reasons I suggest that operations for sliding hiatal hernia such as partial gastrectomy or vagotomy, which aim at diminishing the flow of acid pepsin are not based upon sound premises, unless it so happens that by shortening the stomach the cardia is held down in such a position that the fundus can balloon up effectively and so reconstitute the flap valve. The operation of my choice eliminates reflux from the stomach *and from the duodenum*, and it consists essentially in fixing the fundus to the lower surface of the diaphragm.

To summarize my views about the rationale of operations to cure reflux œsophagitis I believe that the hernia should be reduced because its presence permits reflux: the œsophageal hiatus may sometimes require diminishing in size in the hope that this manœuvre will help to prevent a recurrence of the hernia: the œsophago-gastric angle should be reconstituted by fixing the cardia below the diaphragm and so allowing the fundus of the stomach to balloon up under the dome.

In operating upon these patients to cure reflux the surgeon can, in my opinion, only influence one of the two chief factors concerned in competence of the cardia. He can restore the anatomical alinement of the parts to each other; but he can do nothing to the mucous membrane valve itself. It so happens that, by good fortune, in correcting the first the second corrects itself.

There are two subsidiary points relevant to partial gastrectomy, done for gastric or duodenal ulcer, which are pertinent to this discussion. After partial gastrectomy the cardia is sometimes inefficient

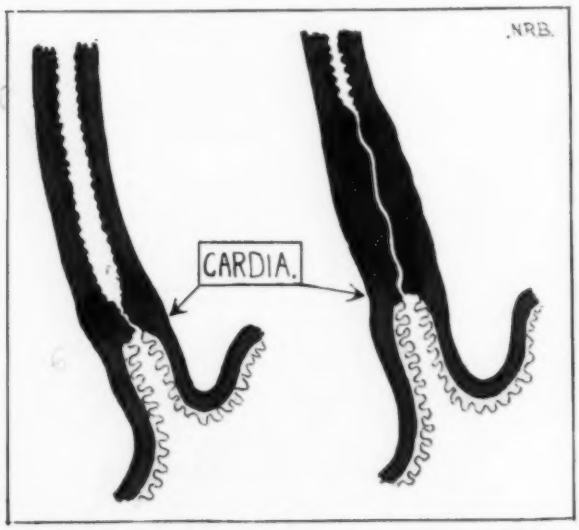



FIG. 265.—Diagram to illustrate the two different types of stricture which occur as a complication of œsophagitis. That on the left is the common linear variety; that on the right represents 'ascending œsophageal fibrosis'. *Red*, œsophageal and gastric muscle coats; *Blue*, œsophageal mucosa; *Yellow*, gastric mucosa; *Black*, stricture. In both cases the stricture reaches up from the cardia.

for a few days, and this, presumably, is due to alteration of the œsophago-gastric angle. The patients complain of heartburn and eructations, which can be relieved by raising the head of the bed. This simple manœuvre was greatly appreciated by one of my colleagues who recently had a part of the stomach removed. The second observation is that a tube

left in the stomach after partial gastrectomy, for drainage or feeding, can make the cardia incompetent, and on two occasions I have seen acute œsophagitis with ulceration at autopsy.

fixation of the mucosa, fibrosis of the muscle, and, eventually, to a stricture in the wall of the œsophagus. There is usually peri-œsophagitis in the mediastinum and the lymph-glands become enlarged and adherent.

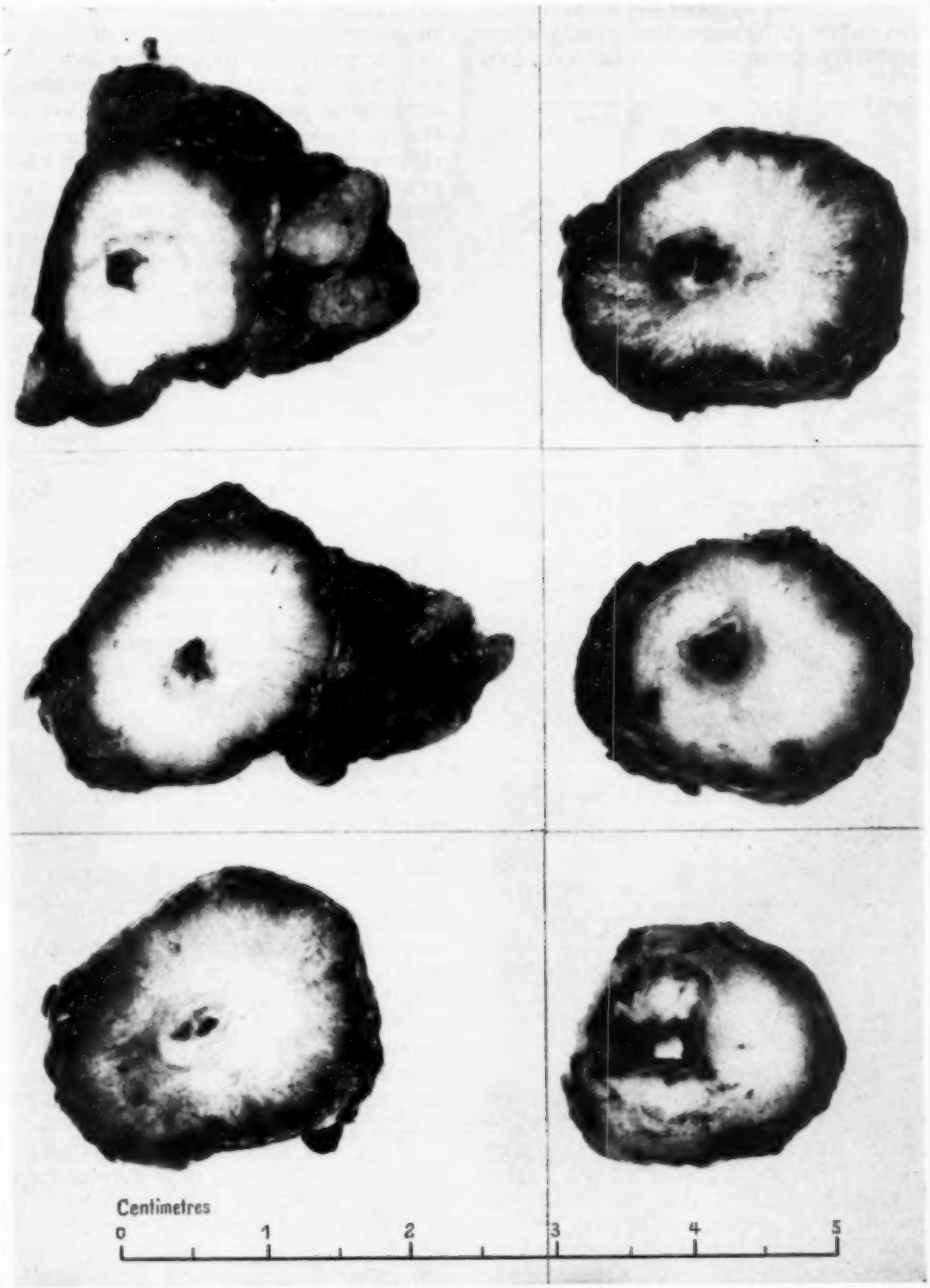



FIG. 266.—Cross-sections at different levels of stenosed segments of an œsophagus removed from a child aged 5, who suffered from a long stricture due to a sliding hiatal hernia. The mucosa has been completely destroyed and the stricture is lined by granulation tissue only. The stricture was removed by Mr. Ronald Belsey, who comments that the fibrosis and thickening of the wall suggests the futility of attempts at dilatation. (*This illustration is reproduced by permission of Mr. R. Belsey and Messrs. Butterworth & Co.*)

The foregoing remarks apply to patients suffering from simple sliding hiatal hernia. In some cases the pathological effects of repeated episodes of digestion of the mucosa of the œsophagus are more serious and extensive. The inflammation transgresses the muscle coats of the gullet and leads to

The problems posed are now different, for not only is progressive dysphagia a prominent symptom, but the cardiac mucosal valve is destroyed (*Fig.* 264). It follows that, *whatever be done about the stricture, the valve at the cardia has been lost forever* and competence will not be restored by repairing the hernia

and replacing the parts in the abdomen. Useless operations will be avoided if this point be understood.

The strictures which occur in these patients are of two varieties (*Fig.* 265). The common type is a linear constriction situated at the œsophago-gastric junction. As this stricture tightens the inflammation due to digestion in the œsophagus immediatly above the stricture gradually diminishes, and, however long

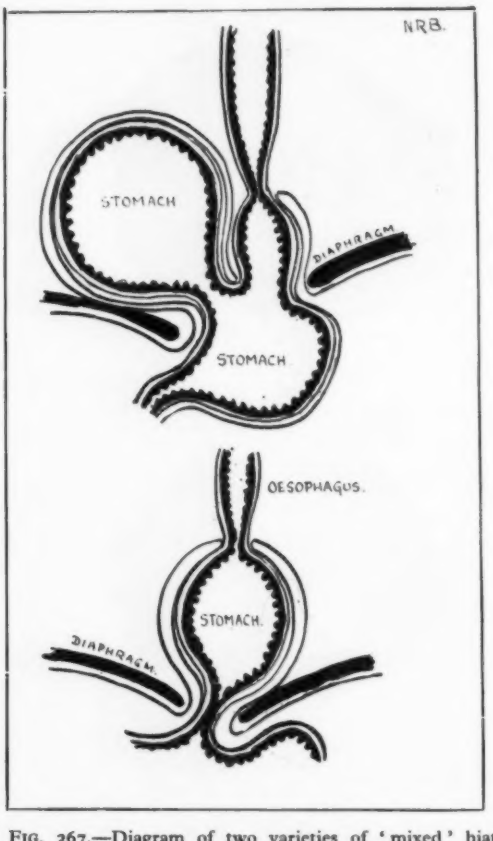



FIG. 267.—Diagram of two varieties of 'mixed' hiatal hernias. Some would regard the lower diagram as depicting a sliding hiatal hernia in which a complete sac existed because there happened to be no bare area in the stomach. The term 'mixed' is used by some to signify that parts of both stomach and œsophagus have herniated; by others it is used to signify that the hernia concerned does not conform exactly to any of the classical types.

the stricture may have been present, the œsophagus above hypertrophies but does not dilate, because its musculature is not paralysed (as it becomes in achalasia) and because the contents can be voided into the pharynx. It follows that, although the stricture is harmful, in that it produces an obstruction, it is nature's way of preventing further reflux. This was effectively demonstrated to me by the following experience. Some years ago a little boy, suffering from sliding hernia and stricture, came to me for treatment. At œsophagoscopy the mucous membrane immediately above the stricture looked normal: it was not inflamed. At the operation I treated the patient by dilating the stricture with bougies and the immediate effect, as regards swallowing, was excellent. The ward sister was so impressed with the result that she persuaded me, three days later, to do a second œsophagoscopy in order to dilate the stricture still further and so "to finish the job". At the second endoscopy the lower œsophagus was already in a state of acute œsophagitis and reflux could be seen as one watched the patulous orifice.

The treatment of sliding hiatal hernia complicated by a linear stricture is of two types. The hernia can be ignored and the stricture dilated, provided reflux can be prevented by insisting that the patient sleeps in the sitting position and takes alkalis. This programme is justified in my opinion in a few young children as a temporary expedient and in some elderly patients. I do not think it should be advised in any other circumstances. If surgery becomes necessary there are only two operations which fill the bill. The first is œsophago-jejunostomy. This is an extensive procedure but one which is well tolerated and gives good results. It consists in removing the stricture, closing the stomach and fixing it below the diaphragm, constructing a loop of jejunum (according to the method practised by Allison and da Silva (1953)) and of anastomosing the jejunum to the open œsophagus. The disadvantages of this operation are that the stomach and duodenum are excluded from the direct flow of food and certain metabolic disorders, which have been stressed by Brain, may cause digestive upsets. But the patient can swallow and can live a reasonably normal life by paying a little attention to diet.

The second operation for stricture which as yet has not been sufficiently tried, was first practised by Brain and so far it promises well. The stricture is excised, the stomach is replaced in the abdomen, and the gap bridged by an isolated loop of small intestine. The loop is mobilized with its mesentery and sewn into the œsophagus above and to the stomach below. I am aware that operations of this type which have been applied to the stomach are falling into disrepute; but circumstances are different when the principle is applied to the lower œsophagus; and, if it works, it has the advantage that the stomach is not by-passed. In 1940 I treated a patient suffering from carcinoma of the œsophagus by excising the growth and constructing a new gullet under the skin in the front of the chest, using a length of isolated small intestine. The operation went well, but failed completely in convalescence because, by mistake, I had put the loop under the skin in such a way that peristalsis was upwards, and the result was that the patient could swallow nothing at all.

I believe that Brain's operation may succeed because the isolated loop retains peristalsis and so prevents reflux of irritating gastric contents.

The second variety of stricture is not linear. It was described some years ago by Brown Kelly under the name of 'ascending œsophageal fibrosis' and occurs particularly in young children: it is rare. The stricture consists of a solid mass of fibrous tissue, which grows up from the cardia for a distance of several inches, and totally replaces the normal muscle coats and mucosa of the œsophagus. Throughout the length of this obstruction a tenuous, irregular chink remains as the only pathway through which the child can swallow (*Fig.* 266). I have not treated such a case, but Belsey (1952) has described several and stressed the severity of the starvation and the difficulties of management. He deprecated

attempts at dilatation by bouginage, regarded gastrostomy as a bad permanent solution but as having some value in preparing starved patients for operation, and stated that excision was essential after the child had been suitably prepared. He resects the upper half or more of the stomach, along with the lower half of the œsophagus, and repairs the gap by fashioning a tube from the greater curve of the stomach. He stated that his results have been good. He is aware of the theoretical disadvantages of anastomosing the stomach to the œsophagus under any circumstances, but regards this operation as the most reasonable solution of the problem at the moment.

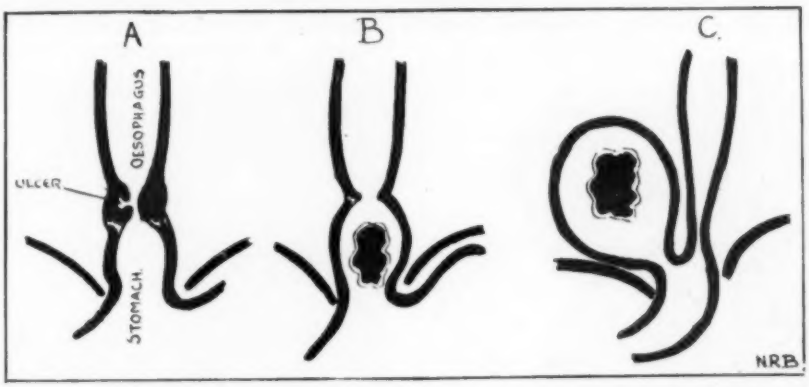



FIG. 268.—Diagram to illustrate the three types of ulcer which occur in connexion with hiatal hernia. A, Œsophageal ulcer, the result of a sliding hiatal hernia. B, Gastric ulcer complicating a sliding hiatal hernia. C, Gastric ulcer complicating a para-œsophageal hernia.

**4. Mixed Hiatal Hernia** (Rolling Hernia).—In addition to the herniæ described above, for which I have suggested some aetiological explanations, there are others in which sliding and para-œsophageal types are mixed and some in which the arterial supply and the peritoneal reflections do not conform to the anatomy I have described (*Fig.* 267). These are unusual numerically as compared with those already described, and frequently cannot be diagnosed exactly before operation. They should be treated according to the principles enunciated above.

Belsey (1954) stated that the 'rolling' type of hernia (by which I take him to mean the variety I am now discussing under the heading 'mixed') is more common than the para-œsophageal, which he says is rare. My experience is the opposite and I suggest that the explanation is that the 'mixed' or 'rolling' hernia occurs more commonly in children and the pure para-œsophageal in adults.

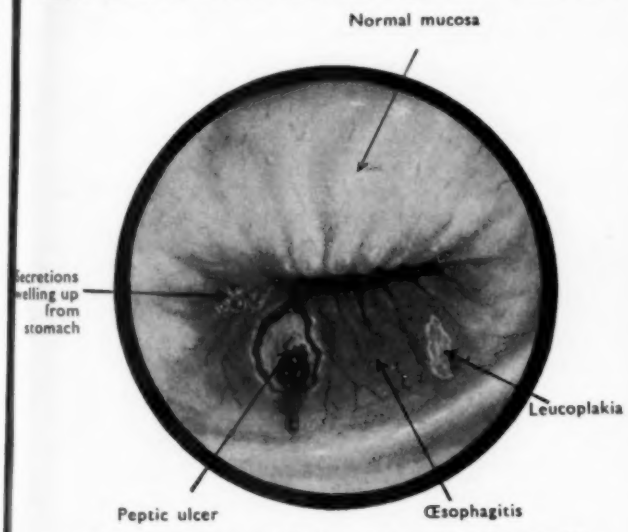



FIG. 269.—Characteristic appearances of 'reflux œsophagitis' and 'peptic ulcer of the œsophagus' as seen at œsophagoscopy.

FIG. 270.—Barium swallow showing a stricture of the gullet caused by a long-standing 'reflux œsophagitis', and also showing a small ulcer in the lumen of the stricture.

## CONCERNING HIATUS HERNIA AND 'PEPTIC ULCER'

Three different varieties of ulceration occur in the œsophagus and stomach in association with hiatus hernia and require recognition because treatment is different (*Figs.* 268–271).

**1. Œsophageal Ulceration** occurs as a part of reflux œsophagitis. In most cases the ulcers are shallow excoriations of the squamous mucous membrane which bleed easily, heal, and recur at variable intervals, and cause no distinugishable symptoms. Belsey has stressed the following important points

FIG. 271.—This specimen shows the area of the 'ulcer', in the previous figure. The specimen was removed from a woman who had a long history of dysphagia: she was treated by excision of the stricture, and of the pouch of stomach below it, and then by œsophago-jejunostomy.

about these ulcers: They are not comparable in any way to gastric or duodenal ulcers; they never cause massive bleeding, although by persistent oozing an anæmia may develop; they do not perforate or become malignant; they are situated immediately above the junction of the gastric and œsophageal mucosæ; they rarely show on a barium swallow and are diagnosed only at endoscopy. Their presence does not alter the management of reflux œsophagitis: but it makes treatment by surgery more urgent because repeated mucosal ulceration predisposes the submucosa to permanent fibrosis, and culminates in destruction of the mucosal flap valve.

**2. Gastric Ulcer in the Protrusion of Stomach in a Sliding Hiatal Hernia or Congenital Short Œsophagus** (*Fig.* 272).—In 1950 I pointed out that these ulcers, which up to that time had been confused with œsophageal ulcers, were true gastric ulcers and behaved in all ways as such. If a stricture is not present above such an ulcer it can be demonstrated as a crater on barium swallow and also at endoscopy; but, if a stricture is present, then diagnosis is difficult pre-operatively because there are no special symptoms or signs which are pathognomonic.

Massive bleeding occurs in some patients and may be due to an acute erosion or to a chronic ulcer, and in the former it is difficult to find the gastric ulcer at operation. In 1953 Allison and Johnstone described 7 patients whom they had treated. All were suffering from reflux œsophagitis, and in 4 a stricture was present above the gastric ulcer. One patient had two gastric ulcers in the mediastinal hernia, one of which had caused massive hæmorrhage; in another perforation had occurred, and in yet another a carcinoma. In my own series, which were found at first by examining museum specimens, the ulcers were large; two had caused the death of the patients by perforating into one of the great vessels of the mediastinum.

Allison pointed out that the ulcers can heal under medical treatment in the same way as any ordinary gastric ulcer, and that a gastric stricture developing below the cardia does not necessarily follow this event. A temporary jejunostomy is a reasonable way of treating the condition in the first instance if the patient is seriously debilitated; but, ultimately, the problem involves curing the hiatal hernia as well as controlling the gastric ulcer.

**3. Gastric Ulcer in the Herniated Stomach of a Para-œsophageal or of a Mixed Hernia.**—This is also a gastric ulcer, but it is situated inside the sac of the hernia. Some surgeons have found these ulcers near to the greater curve of the stomach;

FIG. 272.—The specimen is of the larynx and the upper two-thirds of the œsophagus viewed from behind. The patient died because a large gastric ulcer perforated into the aorta at the level of the hilum of the lung. The œsophago-gastric junction can be seen about 1½ in. higher up. This is an example of a congenital short œsophagus.

that is towards the top of the sac. My own experience is that this may be so if the hernia is truly para-œsophageal (*Fig.* 273); but if the hernia is of the 'mixed' or 'rolling' type, as it often turns out to be, the gastric ulcer lies generally upon the lesser curve. In the latter type of hernia the only part of the stomach which remains below the diaphragm is the prepyloric region and most of the

lesser curve is well above the œsophageal hiatus (*Fig.* 274). The ulcers are true and typical gastric ulcers and they tend to become fixed to the pre-aortic region just below the hilum of the lung. They are difficult to demonstrate pre-operatively by radiography, although it is possible that some residue of barium may stick in the ulcer and become apparent if the patient is turned into the face-down position and screened from the side. The presence of such an ulcer is suggested by persistent pain and almost confirmed if there is a history of hæmatemesis or melæna. Bleeding can be profuse in these cases, and some of the specimens I have examined have come from patients in whom the ulcer has perforated into the aorta.

FIG. 273.—This radiograph shows a large para-œsophageal hiatal hernia. In fact there was a large, perforating, gastric ulcer in the herniated part of the stomach, and from this the patient had bled profusely. The presence of this ulcer was not established by examining the pre-operative radiographs.

It will be obvious that the possible presence of such an ulcer adds not only to the dangers inherent in having one, but increases the complexity of surgical treatment. It is my opinion that these ulcers are sufficiently common to colour the attitude of a surgeon who commonly deals with these cases.

I believe that patients who have para-œsophageal or ' mixed ' hiatal herniæ should be advised to undergo surgical treatment, once diagnosis has been made, unless there is some good reason to the contrary. By so advising the patient may be saved the added dangers of a large gastric ulcer. But I submit that in treating these gastric ulcers it is not always necessary to do a partial gastrectomy, which adds to the severity of an already difficult procedure. It is easier and sufficient to do a sleeve resection of the stomach, if the ulcer is mobile, or to leave the base of the ulcer undisturbed and to do a local excision if the parts are fixed. This opinion is based upon the belief that the ulcer is, in some way, due to the hernia, and, if the hernia be cured, the ulcer should not recur. Moreover, if the ulcer does recur, the hernia will at least have been cured and the ulcer can then be managed upon orthodox lines.

Whatever be done to the ulcer, the hernia must be reduced and the defect in the œsophagus repaired, and it is my experience that the mortality in these cases is high.

FIG. 274.—This specimen was removed from a woman aged 57 who complained of symptoms suggestive of a hiatus hernia and melæna. No ulcer was certainly demonstrated in the radiographs before operation. She had a large ' mixed ' or ' rolling ' hiatal hernia and the only part of the stomach below the diaphragm was the prepyloric antrum. The ulcer was treated by sleeve resection of the stomach, and the specimen shows it situated upon the lesser curve. It was adherent to the aorta in the mediastinum.

I wish to record my debt to P. R. Allison and his colleagues, who have contributed so much to this subject. Some of the anatomical diagrams I have made are similar to those originally devised by Allison.

---

## A NOTE ON THE DEVELOPMENT OF THE HUMAN PNEUMATO-ENTERIC RECESS

BY E. W. T. MORRIS

*From the Anatomy Department,*
*St. Thomas's Hospital Medical School*

It is not possible to discover the relationship of the pneumato-enteric recess to the right crus of the diaphragm from the material available.

Frazer states that the muscle begins to differentiate around the phrenic nerve and migrates from there, so obliterating the middle part of the pneumato-enteric recess and dividing it into an infracardiac bursa above, and the superior recess of the lesser sac below.

This does not appear to be the case in the embryo shown in *Fig.* 276 since the separation is almost complete, yet no muscle is evident, even around the phrenic nerve.

Several embryos of about 14 mm. C.R. length would be needed to determine the usual time relationship between the separation of the recess and the appearance of muscle. If the condition indicated by Frazer is the more usual, it should be possible, with suitable material, to determine the relation of the invading muscle to the recess. If it is more common for an interval to occur between obliteration and the appearance of muscle, then only an embryo with a persistently patent recess could indicate the relationship.

It seems reasonable to suppose that a persistent process must pass either through the right crus or the œsophageal hiatus.

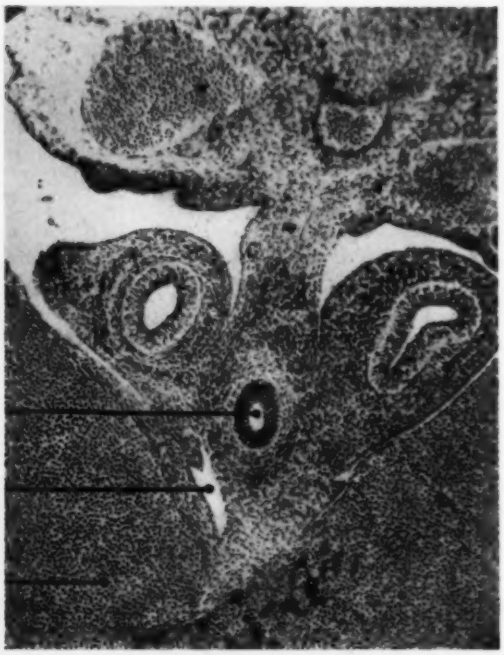



FIG. 275.—Human foetus 8·5 mm. crown rump length (C.R.). The right pneumato-enteric recess (P.E.R.) continuous with the lesser sac, lies in undifferentiated mesenchyme between the liver (L) and the œsophagus (O).

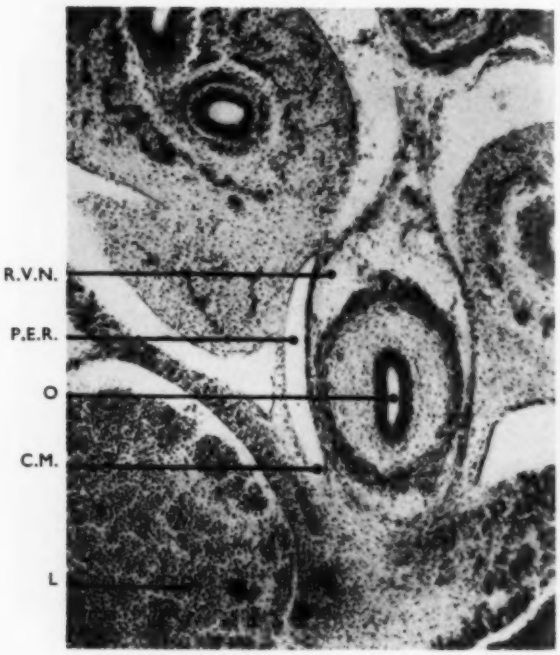



FIG. 276.—Human foetus 14 mm. C.R. The right pneumato-enteric recess (P.E.R.) lies in contact with the œsophagus and right vagus nerve (R.V.N.) and is separated from the liver by an area of condensed mesoderm (C.M.). Caudal to this section a narrow channel, passing through the condensed mesoderm, connects the ventral border of the pneumato-enteric recess with the superior recess of the lesser sac (B.S.). (*Fig.* 277).
No diaphragmatic muscle has differentiated at this stage.

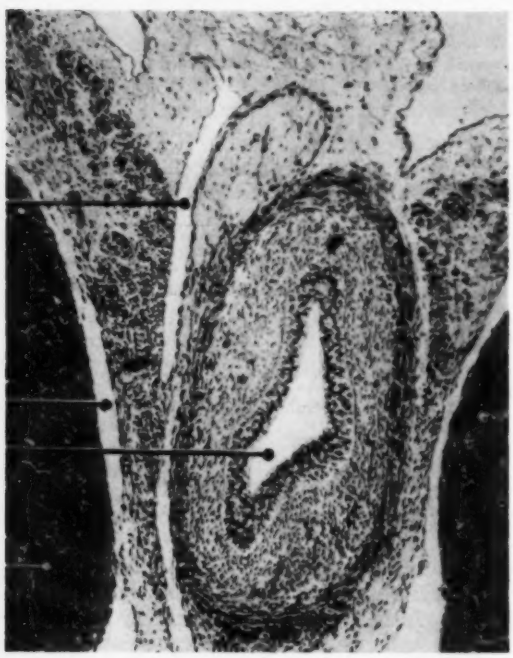



FIG. 277.—Human foetus 25 mm. C.R. The sequestered infra cardiac bursa (I.C.B.), still in contact with the right vagus nerve and œsophagus, is separated from the superior recess of the lesser sac by a sheet of developing muscle in the posterior part of which lies the phrenic nerve.
This sheet when traced caudally occupies a similar position to the right crus in the adult.

## REFERENCES

ALLISON, P. R., and JOHNSTONE, A. S. (1953), *Thorax*, **8**, 87.
— — and da SILVA, L. T. (1953), *Brit. J. Surg.*, **41**, 173.
AYLWIN, J. A. (1953), *Thorax*, **8**, 38.
BARRETT, N. R. (1950), *Brit. J. Surg.*, **38**, 175.
BELSEY, R. (1952), *Modern Trends in Gastroenterology*, (ed. F. Avery Jones). London: Butterworth & Co.
— — (1954), *Ann. R. Coll. Surg. Eng.*, **14**, 303.
DORNHORST, A. C., HARRISON, G. K., and PIERCE, J. W. (1954), *Lancet*, **1**, 695.
HAMILTON, W. J., BOYD, J. D., and MOSSMAN, H. W. (1946), *Human Embryology*, Cambridge: W. Heffer & Sons Ltd.
O'MULLANE, E. J. (1954), *Lancet*, **1**, 1209.

# EPITHELIOMA CUNICULATUM

## A VARIETY OF SQUAMOUS CARCINOMA PECULIAR TO THE FOOT

By IAN AIRD, H. DAINTREE JOHNSON, BERNARD LENNOX, and A. G. STANSFELD

FROM THE DEPARTMENTS OF SURGERY AND PATHOLOGY OF THE POSTGRADUATE MEDICAL SCHOOL OF LONDON, AND THE ROYAL FREE HOSPITAL

We have seen three examples of a tumour of the foot which does not appear to be described in the literature. Probably, as we shall see, it is no more than a very unusual variant on the old theme of squamous carcinoma of the skin. But two at least of our cases (one we only know as a museum specimen) caused both clinicians and pathologists concerned considerable difficulty in diagnosis and treatment, and we have some evidence that similar tumours, though rare, have been seen elsewhere and caused similar difficulties; we believe therefore they deserve description.

Fig. 278.—*Case* 1. Plantar view of the foot when first seen. The small depressions on the summits of several of the bossy projections are sinus openings.

Fig. 279.—*Case* 1. Dorsal view. (The small black lesion is a benign melanoma, unrelated to the main tumour.)

## CASE REPORTS

*Case* 1.—

Clinical History.—A man of 64 presented himself to one of us (I. A.) in 1950 with a very curious swelling of the fore part of the left foot (*Figs.* 278, 279). It formed a bulbous mass on the sole, covered with skin but with many sinuses, most of the latter opening each at the apex of a separate bulge. It was 'squashy' in consistency, and on pressure greasy material with the appearance and characteristically sickly smell of sebum oozed out of these sinuses like toothpaste from a tube. The mass extended right through the foot, and appeared on the dorsum (*Fig.* 279) between the toes, but despite its size and extent it did not appear to be destroying bone, tendon, nerve, or any other important structure. It had been present two years, and had recurred after an excision elsewhere a year earlier. Several biopsies had failed to provide a firm diagnosis. Search for possible infective agents proved fruitless. Finally, the mass continuing to enlarge and the foot being useless, mid-leg amputation was carried out. Convalescence was complicated by fracture through an area of Paget's disease in the tibia of the opposite leg, but the patient was ultimately able to walk well and is now, three years after the operation, fit and free from metastases.

Pathology.—Several biopsies were available for study, but they add no information, and description will be confined to the amputation specimen. This showed no abnormalities except for the mass in the foot. The external appearance of this corresponded to the clinical description. The foot was frozen and then sawn into sagittal slices (*Fig.* 280). The tumour was then seen to be well-defined, filling and expanding the soft tissues of

the sole as far back as the heads of the metatarsals. It consisted of a firm yellowish-white tissue, conspicuously broken up by an intercommunicating series of branching tunnels and clefts, having the pattern on the cut surface almost of rivers draining a marsh, and, imagined in three

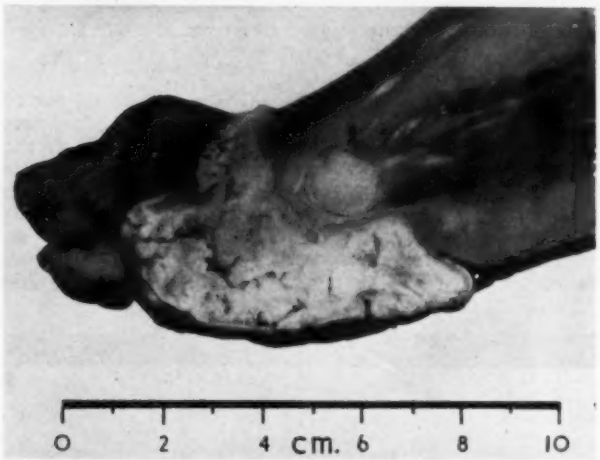



FIG. 280.—*Case* 1. Specimen after sagittal section through the third interosseus space. Note especially the 'rabbit-warren' sinuses.

dimensions, having the (cuniculate) structure of the burrows in a rabbit warren. They opened on the surface to form the sinuses noted clinically. Their walls were irregular, sometimes slightly ragged, sometimes crenated,

FIG. 281.—*Case* 1. Section of one of the bossy projections. The single sinus opening at its summit is seen to be formed by the confluence of several crypts: these are readily seen in the superficial part, but in the deeper part, when the epithelium becomes more tenuous, are increasingly hard to trace at this power. H. and E. (× 4.)

and they were filled with the foul greasy material, extrusion of which was so characteristic a feature *in vivo*.

Histologically the appearances seen are bizarre in the extreme. With the example of later cases to help, interpretation is now relatively easy, but our difficulties when faced with a tumour the bulk of which consisted of material like that seen in the right-hand half of *Fig.* 282 can perhaps be imagined. The sinuses at their orifices (*Fig.* 281) are lined by squamous epithelium, irregularly hyperplastic but not distinguishable from the lining of many non-neoplastic epithelialized sinuses.

Deeper in the sinuses it thins out, and passes more or less abruptly into a thin nondescript epithelium, formed of two or three layers of flattened cells, which lines most of the deeper crypts (*Fig.* 282). That this is still a squamous epithelium, however, is shown by the occasional appearance of thicker areas in which it is better differentiated, and more convincingly, by the adhesion to it of a laminated eosinophilic material with scattered pyknotic nuclei, which has all the appearance of keratin formed by (parakeratotic) keratinization in this same debased epithelium (*Fig.* 283).

Three changes confuse the picture: (*a*) The tissue lining the crypts is flung up into irregular polyps, covered by the same epithelium, which hang in their lumina: while irregular microscopic extensions of the crypts, and solid extensions of the epithelium, everywhere penetrate the surrounding connective tissue (*Fig.* 282). (*b*) This connective tissue is grossly myxoid, especially in the polypi (*Fig.* 283). The singularity of appearance of the sections is much enhanced by the effect of freezing on this waterlogged tissue. (*c*) The overlying epidermis is grossly irregular, with conspicuous spidery prolongations of the rete pegs in many areas (this was a prominent and confusing feature in the biopsies).

On the other hand, areas can be found which suggest the true nature of the lesion (*Fig.* 284). Here strands of squamous epithelium are distributed through the connective tissue in the manner of a carcinoma, though the regularity of cell and nuclear size and the rarity of mitoses suggests no very active growth. Here and there in these strands are foci of keratinization, which are often disproportionately large. It is not difficult to imagine the formation of the large crypts seen elsewhere by the expansion and fusion of large series of similar foci.

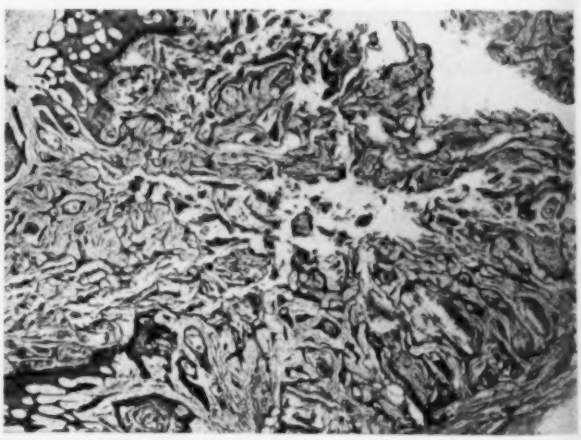


FIG. 282.—*Case* 1. Medium-power view of a characteristic area. A crypt runs horizontally across the centre of the field, and another extends along most of its upper border. The extremely complex arrangement of the epithelial lining is well seen. H. and E. (× 9.)

*Case* 2.—

CLINICAL HISTORY.—When the second patient, a man of 71, was referred to one of us (H. D. J.) in 1952, he presented an appearance strikingly like that of his predecessor (*Figs.* 285, 286). There was the same bulbous mass at the same site, though on the right side in this case, and rather more medially, and from the same sinuses exuded the same foul material. After a biopsy had been reported as showing no evidence of malignancy local excision was attempted, but the sinuses were found to run between the flexor tendons and could only be curetted out. At this stage the resemblance between the two cases was noted (chiefly through the use of the

case at an examination in which one of us was an examiner). Partly because of an uneasy feeling on the part of those responsible for the first case that the patient might have been too radically treated, conservative amputation was performed. The patient remains well, without recurrence.

PATHOLOGY.—The specimen received after the first operation in June, 1952 (*Fig.* 287, upper), was in many

FIG. 283.—*Case* 1. Higher-power view. The squamous nature of the debased epithelium is hardly recognizable, but the flakes of keratin to which it has given rise are unmistakable below and to the right. Note the œdematous stroma (altered by freezing in preparation of the specimen). H. and E. (× 60.)

FIG. 284.—*Case* 1. Relatively carcinomatous area. It is assumed that the crypts are formed by fusion of horn cysts of the type seen here. H. and E. (× 24.)

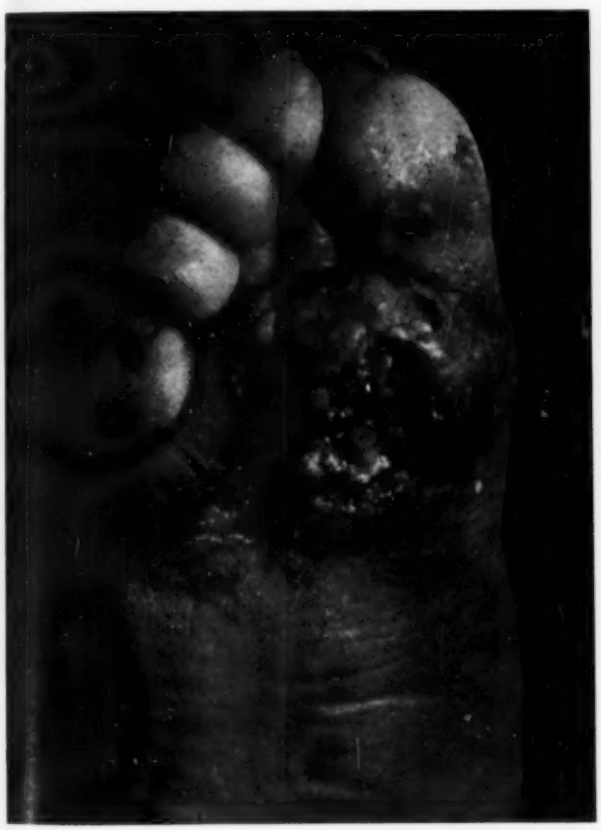


FIG. 285.—*Case* 2. Plantar view, when first seen.

FIG. 286.—*Case* 2. Dorsal view, shortly before amputation.

measures were tried for a year. By May of 1953, however, the tumour had appeared on the dorsum of the foot, and there were enlarged glands in the groin. The glands were excised and found to be free from tumour, but radical excision was obviously necessary and a Syme's

respects remarkably like that seen in the first patient. The surface of the tumour is rather more irregular and broken, the crypts being perhaps larger and their walls more ragged. Histologically (*Fig.* 288) also the picture is very similar: the same sinuses are lined by the same

epithelium. The epithelium is nowhere debased to the same degree as in the first case, the œdema of the stroma is less marked, and the transition to ordinary squamous carcinoma is more obvious, but in general the resemblance is very great. In the amputation specimen (*Fig.* 287, lower) the tumour is seen to be rather more diffuse than in *Case* 1 and the histological appearances (*Fig.* 289) are now in most areas unmistakably those of a squamous carcinoma.

FIG. 287.—*Case* 2. The original lesion, excised in June, 1952, is seen in plantar view above. Below is the amputation specimen, seen in sagittal section through the second toe. The appearances have been modified by the earlier excision, but the same sinuses are visible as in the first case.

*Case* 3.—The third case is represented only by an old specimen found in the Royal Free Hospital museum. It was a gift to the museum from another hospital, and we have not been able to trace its antecedents. But its resemblance both macroscopically (*Fig.* 290) and microscopically (*Fig.* 291) to our other specimens is striking, and in the points on which they differ it is in general intermediate between them. The lack of clinical detail is regrettable, but the fortuitous discovery of this specimen greatly strengthened our belief that in these cases we had a genuinely distinct group.

FIG. 288.—*Case* 2. The first excision. Sinuses very like those of *Case* 1, though the epithelium is better preserved. H. and E. (× 4·3.)

## DISCUSSION

**Pathological.**—We know of no previous record of tumours exactly like these: nor, indeed, of any suggestion of the existence of any form of tumour peculiar to the foot (if we except the viral plantar wart, and even this seems undoubtedly to be common enough at other sites—Lyall and Miles, 1951).

The three tumours have been so uniform in structure and (so far as is known) behaviour, and differ so markedly from anything we have seen at other sites, that the argument for recognizing them as a distinctive group seems very strong. So marked is the uniformity that it does not seem necessary to attempt at this point any generalized description of the pathology. It remains to discuss the nature of the lesion. Five hypotheses have been considered:—

1. *Implantation Dermoid.*—It has been suggested that these are non-neoplastic lesions, produced by forcing normal squamous epithelium into the tissues of the foot by the effect of the mechanical pressure of walking, acting on a small abrasion or an epithelialized sinus. The best evidence against this is the description of the common sinuses of barber's hands by Currie, Gibson, and Goodall (1953). Here we have epithelialized sinuses subjected to reiterated pressure, and in a site anatomically analogous with the sole; yet the modest degree of epithelial proliferation seen in the Glasgow cases is entirely unlike that seen in ours. Nothing resembling the appearances we describe has been reported in the hands of a barber.

2. *Tumour arising in a Dermoid Cyst of the Foot.*—True 'dermoid cysts' in the sense of benign cystic teratomata of the type common in the ovary are excessively rare in the extremities (Willis, 1953), and we know of no authentic example in the foot. Again, though it is not difficult to imagine a defect of development of the digits which would give rise to congenital epidermis-lined cysts in the webs of the toes, we have neither seen such cysts nor know of any record of their occurrence, and there is no evidence that squamous carcinoma arising in a

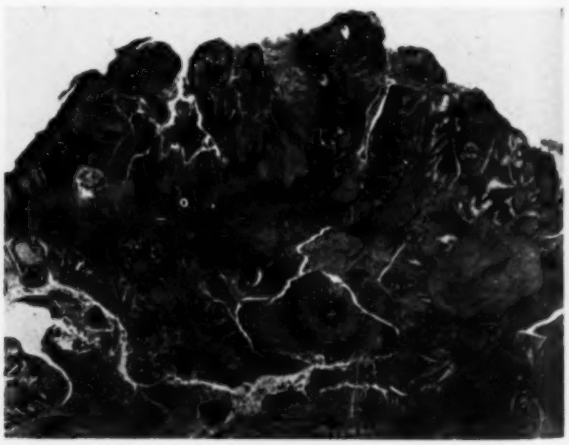


FIG. 289.—*Case* 2. Amputation specimen. Though sinuses are still conspicuous (below and to left), much of the lesion is unmistakably now a squamous carcinoma. H. and E. × 4·3.)

congenital (e.g., branchial) cyst elsewhere possesses any of the characteristics of our present cases.

3. *Tumour of Sebaceous or Hair Follicle Origin.*—There are no hair follicles or sebaceous glands on the sole of the foot. In any event, of the several varieties

FIG. 290.—*Case* 3. Sagittal section through the foot (an old museum specimen).

of tumours known or believed to arise from pilosebaceous structures, including benign calcifying epithelioma (Lennox, 1954) none have this histology.

4. *Plantar Wart.*—Search was made for the readily recognizable specific inclusion bodies of plantar wart (Strauss, Shaw, Bunting and Melnick, 1949; Lyall and Miles, 1951) and none were found.

5. *Squamous Carcinoma.*—We were driven to take this view in the first place largely by exclusion, but

FIG. 292.—Squamous carcinoma of the knee, showing moderate crypt formation. H. and E. (× 6·25.)

consideration of the directions in which squamous carcinoma might be modified by its occurrence on the sole of the foot has led us to adopt it with increasing assurance.

Squamous carcinoma of the skin of the sole of the foot is not common (according to Harnett, 1952, 1·9 per cent of all squamous carcinomata of the skin arise in the foot). A tumour at this site might be expected to differ from the general pattern of squamous carcinoma in two ways:—

*a.* It would tend to produce more keratin than usual. The epidermis of the sole produces (if we except hair matrices and the nail beds) more keratin than any other structure in the body. Though exaggerated by the effect of walking, this characteristic of the plantar epidermis is to a large extent inherent, being present in the newborn infant and

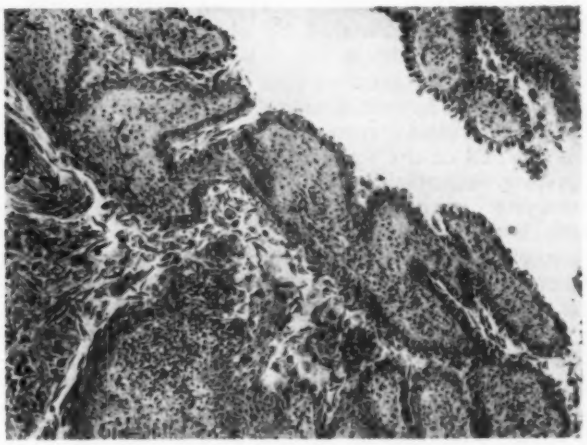


FIG. 291.—*Case* 3. Sinuses like those of *Fig.* 282, though with better-preserved epithelium. H. and E. (× 60.)

being retained after transplantation to a sheltered site (Billingham and Medawar, 1948). It belongs to the curious and interesting group of pseudo-exogenous adaptations (Waddington, 1953). Characters of this type are retained in benign tumours and the better differentiated malignant ones.

*b.* The invasiveness of a carcinoma of low intrinsic malignancy is likely to be exaggerated by

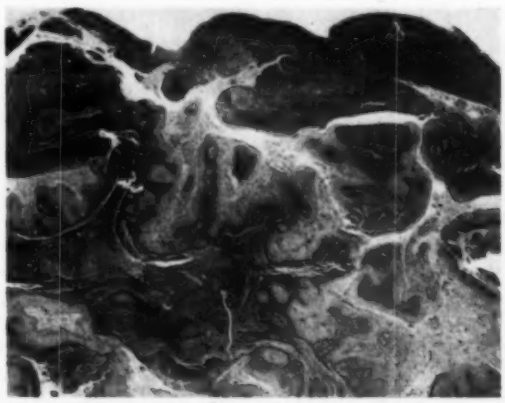


FIG. 293.—Squamous carcinoma of floor of mouth with exceptionally well-marked crypt formation. H. and E. (× 4.)

the effect of walking. The indriven character of benign lesions in this site, exemplified by the corn and the viral plantar wart, is due purely to this mechanical cause. It cannot be doubted that the same process would increase the penetration of the soft tissues of the foot by an early carcinoma.

*c.* The degree of folding of the epithelial surface in epidermal carcinoma, as in epidermal hyperplasia, of the foot and leg, is likely to be further accentuated by œdema of the underlying connective tissues, a result of defective venous drainage in the lower extremity. Dr. I. W. Whimster, who directed our

attention to this factor, pointed out that œdema, enhanced by the presence of infection, might be expected to modify the structure of any tumour of the sole of the foot. He suggested that the bulbous, squashy character of the tumour encountered in these cases might well be due largely to this factor, which results in swollen polypoid masses of water-logged stroma separated by epithelium-lined clefts of exaggerated depth.

We believe therefore that the course of events in our cases has been something like this. A low-grade, highly keratinizing squamous carcinoma has developed on the ball of the foot, possibly on the basis of pre-existing leucoplakia-like change. Reiterated pressure has forced portions of this tumour up into the soft tissues of the foot, probably with some acceleration of growth. Massive keratinization within the tumour has resulted in the formation of multiple small keratinous cysts, and aided by pressure these cysts have joined each other to form larger cysts and irregular chains. Discharge of the contents of these chains of cysts on the surface has resulted in their collapse, leaving the characteristic ragged-walled crypts. The œdema common to many lesions of the foot has modified the stroma. Because the intrinsic malignancy of the tumour is slight, the metastases which might be expected in a tumour of large size with extensive local invasion and relatively rapid growth have not appeared.

Since coming to this conclusion we have been fortified in it by two circumstances: (*a*) Since presenting our cases to the Pathological Society in January, 1954, we have been shown specimens by Dr. J. L. Edwards and Dr. E. M. Ward which we believe to illustrate stages in the evolution of the lesion from early squamous carcinoma. Dr. A. J. M. Reese has shown us a specimen of what appears to be an advanced example of the full-blown tumour, with destruction of the little toe. (*b*) Study of squamous carcinomata elsewhere shows that the formation of quite extensive keratin-filled crypts is not rare, though never in our experience approaching the degree seen in the foot. A Royal Free Hospital case, a tumour of the knee (*Fig.* 292), illustrates exactly what we believe our tumours would have looked like without the additional mechanical factors imposed by their origin in the foot. A bulky tumour of the floor of the mouth, interesting in many respects not relevant here, which we owe to Mr. J. N. Barron and Mr. Maurice Ewing, is illustrated in *Fig.* 293; this is the most extensive degree of crypt formation we have seen outside the foot.

Mention of this last case may serve to introduce one important practical point. In tumours with extensive crypt formation the histological scale of the lesions may be such that a biopsy of ordinary size is quite inadequate to give a satisfactory picture. In all our cases this source of doubt in interpretation of the biopsies has been very marked. Confident histological diagnosis may be impossible without a very large biopsy, or may even await excision of the whole lesion.

**Nomenclature.**—The name 'epithelioma cuniculatum' was given when we were still uncertain of its nature. 'Epithelioma' was used non-commitally in its correct sense (still current in France), implying merely a tumour of epithelium: the resemblance of the crypts to rabbit burrows was responsible for the epithet 'cuniculate'. This name may perhaps be found to have some present value in drawing attention to a tumour which seems to be pathologically and clinically distinct.

**Clinical.**—The clinical appearances of this tumour are almost as distinctive as the pathological. It presents as a 'squashy' tumour of the anterior weight-bearing part of the sole of the foot, with the consistence of an over-ripe orange. It has a tendency to burrow deeply towards the dorsum. From numerous sinuses 'sebum' (actually decomposing keratin) can be liberally expressed, to be recognized easily by smell. We know of no other tumour which has these peculiar characteristics. Amputation seems to become inevitable, and should perhaps be undertaken as soon as the diagnosis is confirmed by the histological appearances which we have described and illustrated.

## SUMMARY

1. Three cases are described of a tumour of the forepart of the foot which can give rise to considerable difficulties in diagnosis.

2. Clinically it is characterized by the presence of a soft bulky mass with extensive invasion of the soft tissues but little destruction of important structures, and by the presence of numerous sinuses exuding foul-smelling greasy material.

3. Pathologically it consists of large and numerous anastomosing crypts lined by squamous epithelium and filled by breaking-down keratin.

4. It is believed that this is a low-grade squamous carcinoma, modified by extreme keratinization and the effects of pressure.

5. Amputation has been necessary in our cases because of extensive local invasion.

6. There have been no metastases.

Our thanks are due to Professor J. H. Dible for his continued interest, to Dr. C. V. Harrison, who did most of the preliminary work on *Case* 1, and to Dr. I. W. Whimster for some helpful suggestions. We are most grateful to Dr. J. L. Edwards, Dr. A. J. M. Reese, Dr. E. M. Ward, Mr. J. N. Barron, and Mr. Maurice Ewing, who have allowed us to include mention of the supporting cases they have shown us. The sections and photomicrographs we owe to Mr. J. Griffin and Mr. C. A. P. Grahame (P.G.M.S. cases), and Miss K. Page and Mr. J. S. Sheppard (Royal Free Hospital cases).

## REFERENCES

BILLINGHAM, R. E., and MEDAWAR, P. B. (1948), *Heredity*, **2**, 29.

CURRIE, A. R., GIBSON, T., and GOODALL, A. L. (1953), *Brit. J. Surg.*, **41**, 278.

HARNETT, W. L. (1952), *Survey of Cancer in London*. London: British Empire Cancer Campaign.

LENNOX, B. (1954), *Trans. St John's Hosp. derm. Soc., Lond.*, **33**, 30.

LYALL, A., and MILES, J. A. R. (1951), *Brit. med. J.*, I, 912.

STRAUSS, M. J., SHAW, E. W., BUNTING, H., and MELNICK, J. L. (1949), *Proc. Soc. exp. Biol., N.Y.*, **72**, 46.

WADDINGTON, C. H. (1953), *Endeavour*, **12**, 134.

WILLIS, R. A. (1953), *Pathology of Tumours*, 2nd. ed., 943. London: Butterworth & Co. Ltd.

# OBSERVATIONS ON THE VASCULARIZATION OF THE HUMAN AND RABBIT THYROID GLAND

By T. D. REILLY

DEPARTMENT OF ANATOMY, UNIVERSITY OF LIVERPOOL

LIGATION of the thyroid arteries has been practised for many years in the operative treatment of hyperthyroidism. Prior to the use of iodine in the preoperative preparation of the patient, ligation of one or more of the thyroid arteries was advocated in an attempt to reduce the degree of toxicity before carrying out the more radical operation of partial thyroidectomy.

To-day many surgeons ligate these vessels at the beginning of the operation as a hæmostatic measure. De Quervain (1923) recommends ligation of the four main thyroid arteries, superior and inferior, as a preliminary step in the operation, and has only observed 3 cases of transient tetany after 4000 operations. This means that the arterial supply of the parathyroids and the residual thyroid tissue depends upon the establishment of a collateral circulation due to the opening up of the anastomoses which connect the thyroid arteries with each other and with neighbouring vessels. Although this collateral circulation in man has been studied by many workers in the past, its functional aspect in experimental animals has received little or no attention. This communication describes an investigation of the vascular pattern of the rabbit's thyroid gland, and the effects of ligation of the principal thyroid arteries, together with observations made from a study of the vascularization of the human thyroid gland.

## ARTERIAL SUPPLY IN THE RABBIT

### PROCEDURE

The normal arterial supply of the thyroid gland was determined in ten mature rabbits using retrograde injections of Micropaque (Damancy & Co. Ltd.) into the lower part of the thoracic aorta immediately after sacrifice by an overdose of intravenous nembutal. After radiography, the cervical and thoracic regions were carefully dissected and cleared by the Spalteholtz technique.

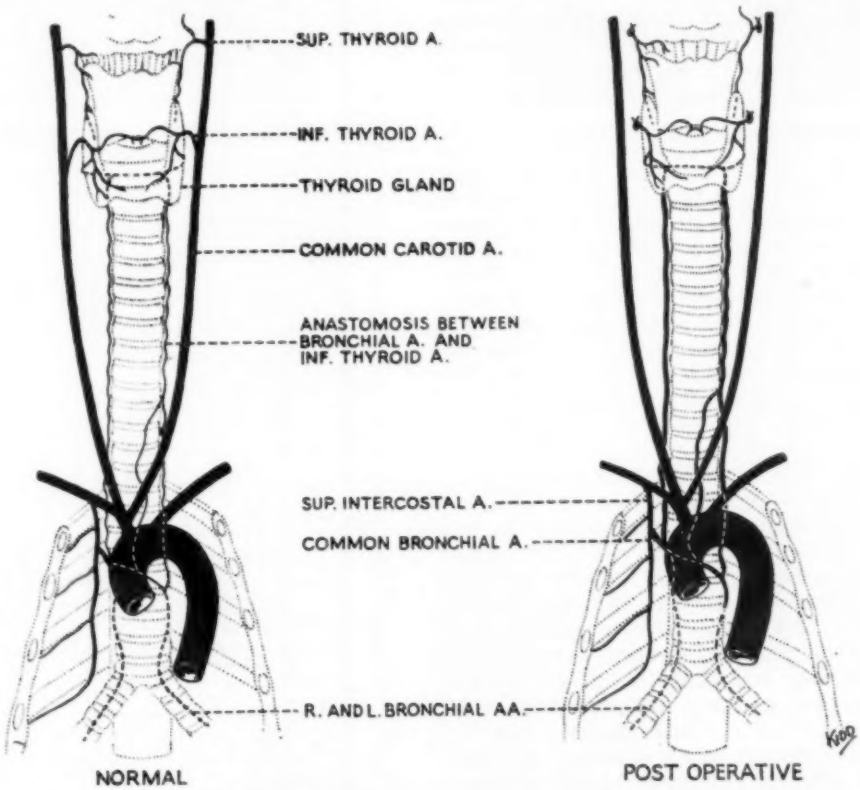



FIG. 294.—A drawing illustrating the arterial supply of the rabbit's thyroid gland before and after ligation of the four principal arteries.

### VASCULAR PATTERN

The rabbit's thyroid gland is supplied by two arteries on each side, which arise from the common carotid (*Fig.* 294). The superior thyroid artery arises well above the level of the thyroid gland and is chiefly concerned in supplying the larynx and the neighbouring muscles. Its glandular branch is very

small and helps to supply only the upper pole on each side. The inferior thyroid artery supplies most of the thyroid gland and anastomoses with its fellow of the opposite side between the trachea and the œsophagus. Although these arteries are not strictly comparable to the human superior and inferior thyroid arteries, the territory of distribution of the superior thyroid artery closely corresponds to that supplied by the extraglandular branches of the human superior thyroid artery, while the inferior thyroid artery in the rabbit supplies the remainder.

In every case a very fine anastomosis was seen on each side connecting the tracheal branch of the (inferior) thyroid artery with the tracheal branch of the bronchial artery. The rabbit usually has a common bronchial artery which arises from the right superior intercostal artery, and passes behind the trachea, where it divides into a right and a left bronchial artery. In three cases these arteries arose separately from the right superior intercostal artery. This anastomosis is situated in the interval between the œsophagus and the trachea, and corresponds to a similar anastomosis which has been shown to be present in the human (Curtis, 1930).

## EXPERIMENTAL METHODS

In a series of rabbits the four thyroid arteries were interrupted as close as possible to the common carotid, using intravenous nembutal as an anæsthetic. As the arteries are very short it was found better to interrupt them by means of diathermy instead of the usual method of division between ligatures. Each artery was caught separately on a fine hook made at the end of a seeker. The seeker was then touched with a diathermy needle for a few seconds and the coagulated portion divided with fine scissors. The rabbits operated on comprise two groups :—

*Group* 1.—All four thyroid arteries were interrupted in four mature rabbits (2–3 kg. in weight) as described. Two rabbits were sacrificed at the end of a week, and the other two at the end of the second week. Micropaque was injected into the thoracic aorta as before and the specimens dissected and cleared.

*Group* 2.—In this group twelve rabbits were used. Nine of the rabbits belonged to one set of litter mates and were ten weeks old at the time of operation. The other three rabbits were from another set of nine-week-old litter mates. Seven of these rabbits were subject to an operation in which all four thyroid arteries were interrupted as before. The other five rabbits were used as controls. In the control animals a sham operation was performed without interfering with the thyroid arteries. After the animals had recovered from the anæsthetic they were kept in the same room under similar conditions of temperature and humidity and were fed on the same diet. The daily body-weight was recorded in each case (*Table I*).

Two of the experimental animals were sacrificed at the end of two weeks, and one after three weeks. Micropaque was injected as described above and the specimens were dissected and cleared. The four remaining experimental animals were used for histological studies of the thyroid gland ; two were sacrificed at the end of one week, one after two weeks, and one after three weeks.

*Table I.*—The Daily Body-weights following Ligation of the Thyroid Arteries in the Experimental Animals

| Days after Operation | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Weights of Control Animals (g.) | X | 1056 | 1062 | 1096 | 1116 | 1118 | 1134 | 1153 | 1145 | 1182 | 1198 | 1195 | 1229 | 1212 | 1225 | 1234 | 1256 | 1318 | 1338 | 1386 | 1454 | 1461 |
| | X | 1034 | 1050 | 1130 | 1123 | 1126 | 1160 | 1164 | 1188 | 1216 | 1232 | 1310 | 1418 | 1416 | 1490 | 1466 | 1500 | 1512 | 1564 | 1585 | 1572 | 1590 |
| | X | 952 | 962 | 1003 | 1010 | 1042 | 1074 | 1052 | 1095 | 1114 | 1170 | 1220 | 1290 | 1296 | 1370 | 1384 | 1394 | 1409 | 1395 | 1426 | 1442 | 1478 |
| | | 450 | 474 | 540 | 582 | 612 | 600 | 666 | 674 | 734 | 716 | 701 | 749 | 753 | 762 | 781 | 824 | 886 | 945 | 948 | 962 | 971 |
| | | 462 | 478 | 523 | 582 | 598 | 602 | 670 | 666 | 721 | 707 | 690 | 734 | 746 | 776 | 786 | 844 | 898 | 952 | 953 | 945 | 960 |
| Weights of Operated Animals (g.) | X | 928 | 914 | 948 | 953 | 1017 | 1038 | 1038 | 1041 | 1073 | 1090 | 1130 | 1206 | 1242 | 1305 | 1340 | 1381 | 1403 | 1425 | 1461 | 1488 | 1496 |
| | X | 1334 | 1333 | 1368 | 1380 | 1395 | 1458 | 1482 | 1501 | 1512 | 1536 | 1582 | 1662 | 1662 | 1704 | 1730 | 1722 | 1750 | 1764 | 1802 | 1848 | 1867 |
| | X | 910 | 905 | 969 | 956 | 979 | 1001 | 996 | 1034 | 1042 | 1035 | 1062 | 1115 | 1142 | 1199 | 1201 | | | | | | |
| | X | 1019 | 1018 | 1064 | 1039 | 1077 | 1081 | 1078 | 1116 | 1126 | 1130 | 1150 | 1250 | 1262 | 1330 | 1364 | | | | | | |
| | | 440 | 454 | 502 | 569 | 576 | 610 | 645 | 656 | 670 | 668 | 685 | 702 | 715 | 760 | 762 | | | | | | |
| | | 1090 | 1106 | 1148 | 1152 | 1170 | 1193 | 1223 | 1225 | | | | | | | | | | | | | |
| | | 1155 | 1152 | 1205 | 1229 | 1237 | 1263 | 1272 | 1290 | | | | | | | | | | | | | |

X — Weights which have been used to obtain the growth rates (*Fig.* 297).

## RESULTS

The thyroid glands were removed together with the adjoining portions of the larynx and trachea. After fixation in formol saline the specimens were decalcified for two weeks using 8 per cent nitric acid in an aqueous solution of picric acid. The glands were then sectioned serially at 10$\mu$ and stained with Ehrlich's hæmatoxylin and eosin. The histological structure of the thyroid glands of the operated animals was compared with that of the control animals. Although there were individual variations in the size and shape of the follicles, all the glands were considered to be within normal limits (*Figs.* 295, 296).

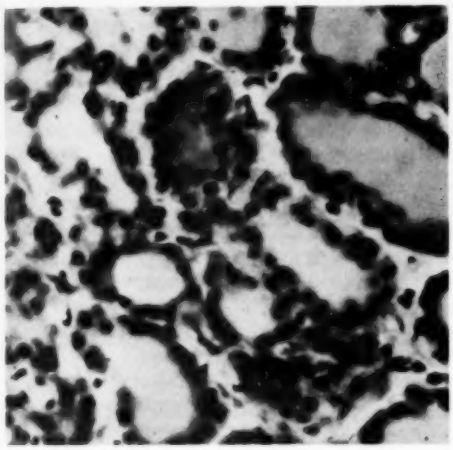


FIG. 295.—Histological structure of the normal rabbit's thyroid gland. (× 380.)

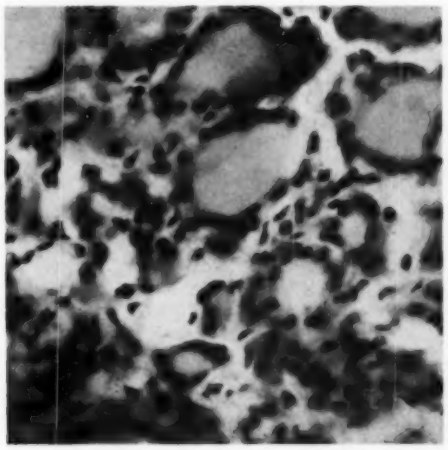


FIG. 296.—Histological structure of the rabbit's thyroid gland three weeks after ligation of the principal thyroid arteries. (× 380.)

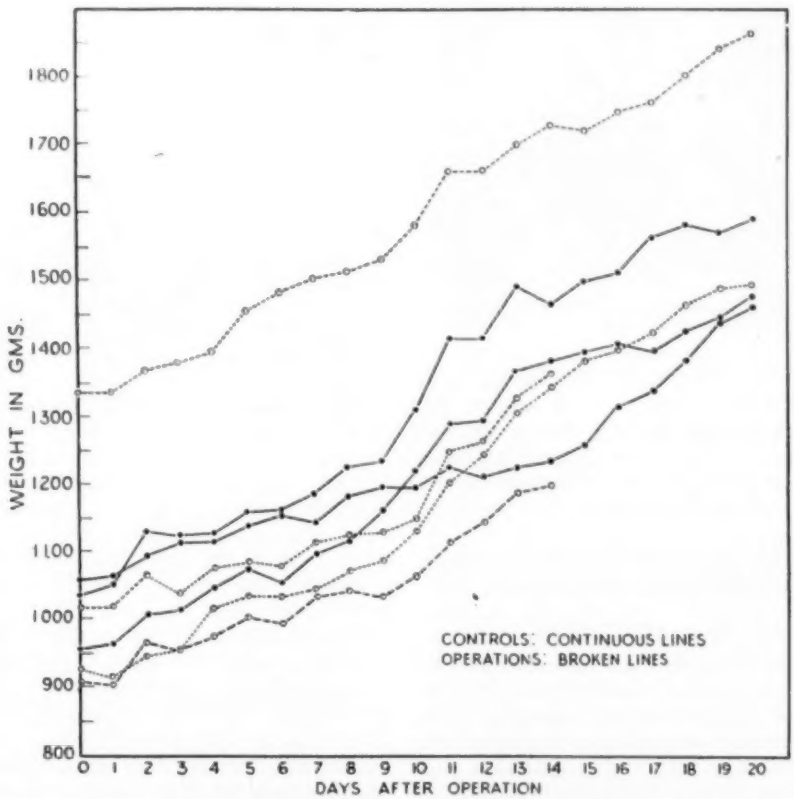



FIG. 297.—Graphs showing the growth rate of rabbits following interruption of thyroid arteries as compared with their litter mate controls.

## COLLATERAL CIRCULATION

In every case in which this was studied the thyroid gland was now supplied by a vessel formed by the tortuous enlargement of the anastomosis

between the tracheal branch of the inferior thyroid artery and the tracheal branch of the bronchial artery on each side (*Fig.* 294). These were the only two vessels remaining to supply the thyroid gland.

### GROWTH RATE

It was considered that any variation in growth rate from the controls after the operation would indicate disturbance of thyroid secretion and possible damage to the thyroid. When the body-weights of the experimental animals were plotted against the number of days post-operatively and compared with similar graphs obtained from the control animals, no alteration in the growth rate was observed during the period of examination (*Fig.* 297).

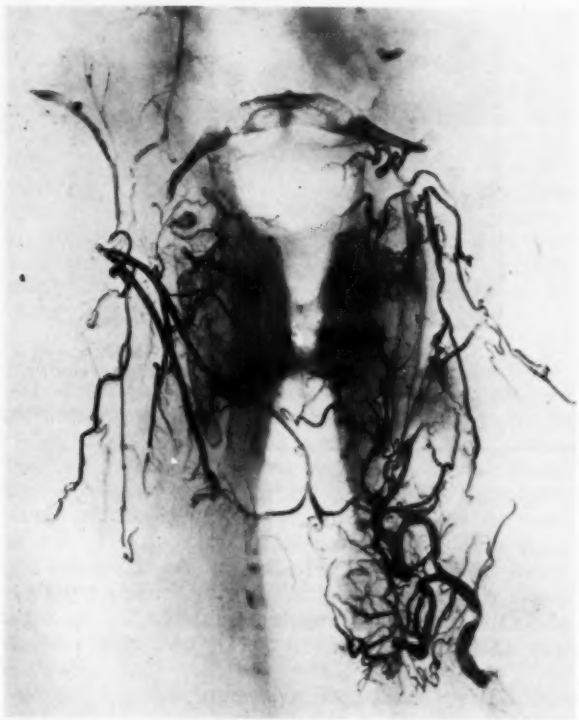


FIG. 298.—Arteriograph of human thyroid gland showing an abnormal cricothyroid artery.

## THE ANASTOMOSES BETWEEN THE THYROID ARTERIES IN THE HUMAN

### MATERIAL AND METHODS

The anastomoses between the thyroid arteries were examined in a series of twelve post-mortem specimens, the ages of the subjects ranging from 25 to 65. One of the specimens was obtained two months after a partial thyroidectomy had been performed. At operation in this specimen three of the main thyroid arteries had been ligated: on the left side the two glandular branches of the left superior thyroid together with the inferior thyroid artery; on the right side the anterior glandular branch of the right superior thyroid. In all of these specimens the entire soft tissues of the neck were removed prior to investigation.

In the normal thyroid glands one superior thyroid artery was dissected out at its origin and a cannula tied into it. After a preliminary irrigation of vessels with normal saline, a 10 per cent suspension of bismuth oxychloride was injected at a pressure of 200 mm. Hg. Vessels which leaked during the injection were tied off until no further leakage took place. After maintaining the pressure for a further five minutes the superior thyroid artery was ligated and the specimen radiographed.

In the case of the operated specimen the same procedure was effected after inserting a cannula into the right common carotid artery.

### RESULTS

**Normal Specimens.**—In 2 cases all the four thyroid arteries were filled with the suspension. In 5 cases both superior thyroid arteries, but neither of the inferior thyroid arteries, were filled. In 2 cases only the injected superior thyroid artery, and in 1 case the superior and inferior thyroid arteries on the side of injection only, were filled. In 1 case the two superior thyroid arteries and one inferior thyroid artery had been filled (*Fig.* 298). In no case was a thyroidea ima present. These results show that the anastomoses between the thyroid arteries is often less than arterial size, a fact which is not often realized.

In two of the specimens the cricothyroid branch of the superior thyroid artery was observed to take an abnormal course (*Figs.* 298, 299). Usually the

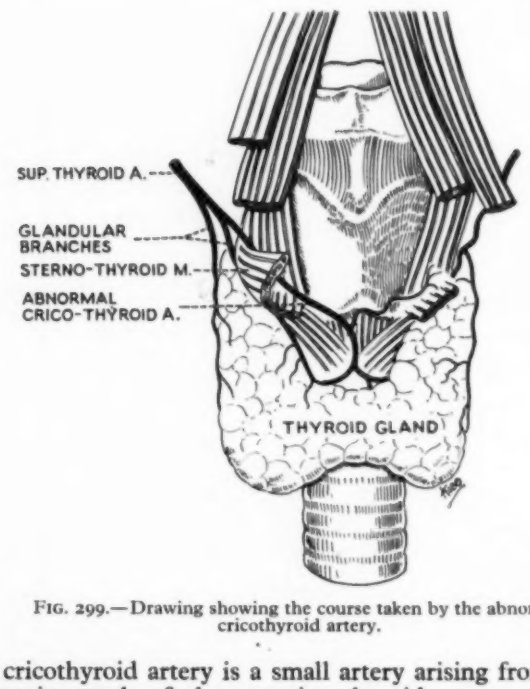



FIG. 299.—Drawing showing the course taken by the abnormal cricothyroid artery.

cricothyroid artery is a small artery arising from the main trunk of the superior thyroid artery. After giving off some small muscular branches it ends by sending a small twig through the cricothyroid membrane. Occasionally it arises from the anterior glandular branch of the superior thyroid artery and takes a recurrent course upwards to reach the cricothyroid membrane (Streckeison, 1886). In the two specimens mentioned the cricothyroid artery took

origin from the trunk of the superior thyroid artery, and was as large as the parent trunk. After passing above the sternothyroid muscle it passed towards the cricothyroid membrane, giving off a small twig to it. At this point it turned downwards across the cricothyroid membrane to supply the isthmus of the gland. The abnormal course taken by the cricothyroid artery was first described by Streckeison, but its description is omitted from most of the current text-books on anatomy. If its presence were unsuspected it could be the source of severe hæmorrhage in the operation of laryngotomy.

**Operated Specimen.**—The anastomoses which have opened up to supply the gland in this specimen are as follows (*Fig.* 300) :—

1. The extraglandular anastomosis between the superior laryngeal branch of the trunk of the superior thyroid and the inferior laryngeal branch of the inferior thyroid artery on both sides.
2. The anastomosis between the posterior glandular branch of the right superior thyroid and the inferior thyroid artery on the posterior surface of the remaining thyroid tissue.
3. The anastomosis between the suprahyoid branch of the lingual artery and the infrahyoid branch of the superior thyroid artery.
4. A large tortuous anastomosis between the two inferior thyroid arteries passing between the trachea and the œsophagus.
5. An anastomotic vessel lying in the interval between the trachea and the œsophagus on the right side connected with the right inferior thyroid artery.

## DISCUSSION

The thyroid gland receives a very rich blood-supply for its size; the volume flow in man per 100 g. of thyroid tissue is 560 c.c. per minute (Best and Taylor, 1950). At first sight it would appear that ligation of all the principal arteries might result in well-defined changes in the histological structure of the gland. The experiments on the rabbit thyroid gland reported in this investigation show conclusively that this is not the case. This is due to two facts: First, there is no absolute impairment of the blood-flow to the organ; the change is purely relative owing to the anastomoses between the thyroid arteries and neighbouring vessels (Pettenkofer, 1914). Secondly, these anastomoses are capable of dilating to form large vessels after a very short interval.

When all four thyroid arteries are ligated close to the gland during the course of a partial thyroidectomy a less radical interference with the arterial supply occurs. Here only the glandular branches of the superior thyroid arteries are ligated, leaving the main trunk and extraglandular branches intact. Thus anastomotic channels are left connecting the trunk of the superior thyroid artery with the distal part of the ligated inferior thyroid artery, in addition to the anastomoses with extrathyroid vessels.

Most authors describe a rich anastomosis between all the thyroid arteries. Wangensteen (1929), using Indian ink as an injection medium, observed this. Mauro (1950), using a methylene blue preparation, found that the superior and inferior thyroid arteries are connected in 45 per cent of cases by a posterior longitudinal anastomotic channel on the posteromedial surface of the lateral lobe of the gland. In the other 55 per cent the anastomoses are multiple. Pettenkofer (1914) describes an extraglandular anastomosis between the superior laryngeal branch of the superior thyroid artery and the inferior laryngeal branch of the inferior thyroid artery. The superior thyroid arteries are described as anastomosing with each other via the pharyngeal, cricothyroid, and anterior glandular branches.

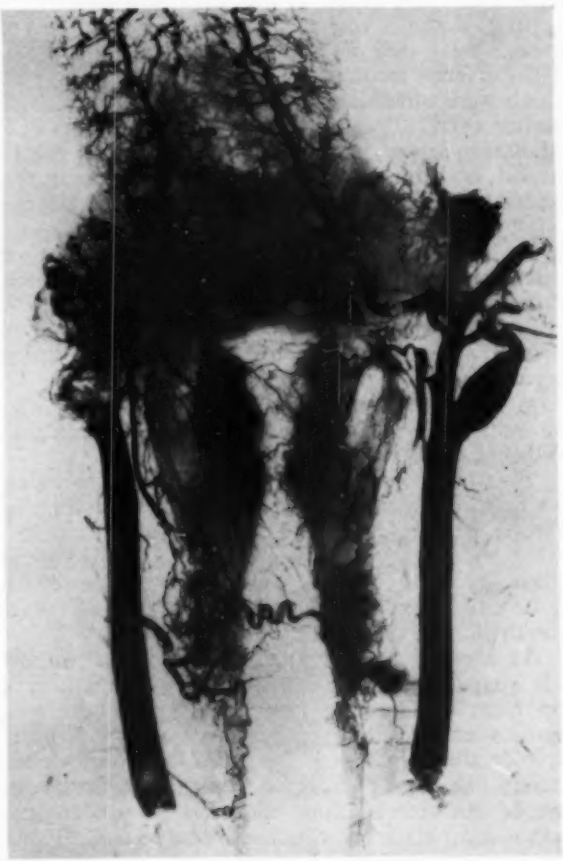


FIG. 300.—Arteriograph of the vessels supplying the residual thyroid tissue two months after partial thyroidectomy.

On the other hand, Streckeison (1886), in his observations on dissecting-room cadavers, found that the visible anastomoses between the thyroid arteries are scanty. Halstead and Evans (1907), using vermilion, which only passes through the capillaries with difficulty, claimed that it was impossible in many cases to fill all the vessels by injecting a single artery. This apparent discrepancy between the results of various workers is accounted for by the fact that although there is a rich anastomosis between all the thyroid arteries it is often composed of vessels less than arterial size, as mentioned above. Only when injection techniques are used which employ substances capable of passing through capillaries and smaller arterioles is it possible to demonstrate this rich anastomosis in every case. Under conditions of relative ischæmia these anastomoses can open up into large vessels connecting all

the thyroid arteries. This has already been demonstrated by Wangensteen (1929) in a study of the vascularization of goitrous thyroid glands.

Curtis (1930) has demonstrated the important anastomoses between the thyroid arteries and neighbouring vessels in man. He employed a retrograde injection of hot thin carmine gelatin into the thoracic aorta below the origin of the bronchial arteries after ligating certain vessels. The four main thyroid arteries were tied off together with bilateral ligature of the arteries leading away from the cervical region, which were obviously not concerned in the collateral anastomosis. These included the second part of the subclavian artery, the terminal portion of the external carotid, and the internal carotid. By means of these experiments Curtis was able to demonstrate the main points of anastomosis, as follows :—

1. Between the pharyngeal branches of the superior thyroid artery and the pharyngeal branches of the ascending pharyngeal.

2. Between the infrahyoid branch of the superior thyroid artery and the suprahyoid branch of the lingual artery.

3. Between tracheal and œsophageal branches of the inferior thyroid arteries and tracheal branches of the bronchial arteries.

This last anastomosis has been shown to enlarge to a considerable degree in the rabbit when the main thyroid arteries are ligated. It is fully capable of taking over the complete vascularization of the rabbit's thyroid gland without any significant change in its histological structure or alteration in the growth rate of the animal.

As a similar anastomosis exists in the human, it is suggested that its enlargement could play an important part in the vascularization of the parathyroids and residual thyroid tissue after a partial thyroidectomy in which ligation of all four thyroid arteries has been performed. Although the greater part of the arterial flow has been cut off in these cases a comparatively minor increase in the collateral circulation should be adequate to preserve the parathyroids and residual thyroid tissue, since the volume of thyroid tissue has been reduced to a relatively insignificant amount by the operation itself.

## SUMMARY

1. The rabbit's thyroid gland is supplied by two arteries on each side which arise from the common carotid together with an accessory supply derived from a fine anastomosis between the bronchial arteries and the main thyroid artery.

2. Ligation of the principal thyroid arteries in the rabbit results in no significant alteration of the histological structure of the thyroid gland or change of growth rate during the period examined. This is due to the rapid enlargement on each side of the anastomosis between the bronchial arteries and the main thyroid artery.

3. The anastomoses between the thyroid arteries supplying the human thyroid gland are often less than arterial size. In two cases out of twelve examined the cricothyroid artery was abnormally large and descended across the cricothyroid membrane to supply the isthmus of the thyroid gland.

4. The vascularization of the residual thyroid tissue, after partial thyroidectomy, has been examined in one case two months after the operation. It is suggested that the anastomoses between the tracheal and œsophageal branches of the inferior thyroid artery and bronchial arteries, which are so important in maintaining the vascularization of the rabbit's thyroid gland, might have a similar function in the human under identical conditions.

This work was aided by a grant from the Medical Research Council. My grateful thanks are due to Professor R. G. Harrison for his help and encouragement during this investigation.

I also wish to thank Mr. L. G. Cooper, Miss B. Birkett, and Mr. C. FitzSimon for their technical assistance.

## REFERENCES

BEST, C. H., and TAYLOR, N. B. (1950), *The Physiological Basis of Medical Practice*, 5th ed., 180. London: Baillière, Tindall & Cox.

CURTIS, G. M. (1930), *Surg. Gynec. Obstet.*, **51**, 805.

ENDERLEN, E., and HOTZ, G. (1918), *Z. angew. Anat.*, **3**, 57.

HALSTEAD, W. S., and EVANS, H. M. (1907), *Ann. Surg.*, **46**, 489.

MAURO, C. (1950), *G. ital. Chir.*, **6**, 384.

PETTENKOFER, W. (1914), *Beitr. klin. Chir.*, **93**, 275.

DE QUERVAIN, F. (1923), *Ibid.*, **128**, 197.

STRECKEISON, A. (1886), *Virchows Arch.*, **103**, 131.

WANGENSTEEN, O. H. (1929), *Surg. Gynec. Obstet.*, **48**, 613.

# METASTATIC HYPERNEPHROMA OF THE THYROID GLAND

By G. GORDON BRUCE and W. MICHIE, Aberdeen

In the embolic dissemination of malignant tissue cells there exists a preferential tissue affinity for different types of malignant growth. Certain organs, such as liver and lung, prove ready hosts for many primary neoplasms. Bone shows a selective affinity for deposits from breast, bronchus, and prostate. In contrast the thyroid, though quite commonly the site of a primary tumour, enjoys a relative immunity to carcinomatous metastases. Statistics confirm this. Willis in 1931 reviewed 47 metastatic growths of thyroid, and added 10 personal cases from a total of 170 consecutive autopsies. Rice (1934), in a series of 89 autopsies of patients dying of malignant tumours, found 9 cases in which the thyroid had carcinomatous deposits, albeit microscopic in 5, and suggested that a more intensive search would reveal a higher incidence. Mayo and Schlicke (1941) stated that the total number of cases until then was

Fig. 301.—*Case* 1 (A.R.I. 988/45). Left lobe of thyroid, bisected, showing three highly cellular and opaque nodules of tumour tissue in right lateral half of photograph and two more coalescent nodules of similar appearance in lower pole. The sixth nodule in medial half of upper pole is semi-translucent and represents a 'fœtal adenoma' of the thyroid. (Natural size.)

less than 200, of which 19 were from the files of the Mayo Clinic. Of these 19 cases, 2 were confirmed post-operatively as secondary deposits of hypernephromas. Since that date 3 further cases of secondary hypernephroma in thyroid have been reported from the Mayo Clinic (Long and Black in 1945; Beahrs, Ginsberg, and Miller in 1953), making a total of 5 in over 100,000 thyroidectomies; in contrast, the incidence of primary malignancy in the same series was given as 2 per cent.

In a series of 1600 thyroidectomies performed in the Royal Infirmary, Aberdeen, in which the incidence of males to females was approximately one in ten, there were 87 cases (5·3 per cent) of primary malignant tumours, with an interesting preponderance in males of 7 per cent compared with 5 per cent in females. Four cases of secondary malignant disease were found, one from colon, one from rectum, and the remaining two from hypernephromas, which are now described in detail.

## CASE REPORTS

*Case* 1.—(A.R.I. 988/45: A.R.I. 848/32: P.M. 355/51.)

J. S., a female patient aged 52, was admitted to hospital in 1932 with hæmaturia, which on investigation was found

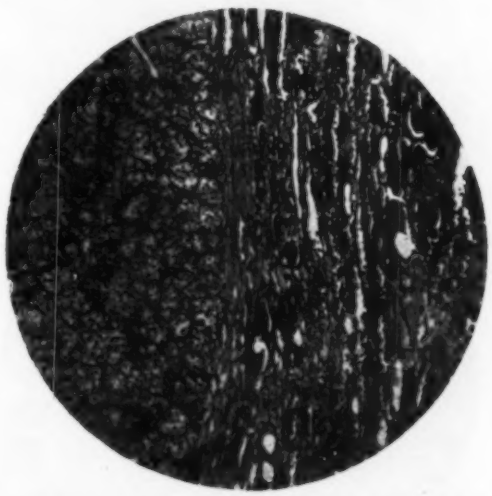


Fig. 302.—*Case* 1 (A.R.I. 988/45). Margin of one of opaque cellular tumours of thyroid invested by fibrous capsule. (× 50.)

to be of right renal origin. Nephrectomy was performed and on section (A.R.I. 848/32, *see Figs.* 304, 305) a hypernephroma was found. She remained well until 1944, when she noticed a painless swelling in her neck. The following year she became breathless on exertion, with occasional palpitation. On admission her pulse-rate was 90, her blood-pressure 194/116. Tremor was present but no exophthalmos. Her basal metabolic rate was −3 per cent. A nodular enlargement of the right lobe of the thyroid was found, with a right Horner's syndrome. Radiography of the chest showed moderate enlargement of the heart in all diameters, and an electrocardiogram gave evidence of a right bundle-branch block. Both cords were normal. At operation the right lobe of the thyroid was removed.

Pathological Report (Professor J. S. Young).—The specimen received was ovoidal (A.R.I. 988/45), measuring 6·5 × 5 cm. in its main diameters and presenting a smooth surface. The bisected specimen (*Fig.* 301) revealed five yellowish-white opaque cellular nodules, measuring up to 2½ cm. in diameter and a sixth semitranslucent encapsulated nodule. Microscopically, all the opaque nodules alike presented a histological pattern immediately suggestive of a renal carcinoma (hypernephroma) (*Figs.* 302, 303). Since all of the nodules were invested by a well-formed fibrous capsule, however, it was considered that the five opaque tumours were more likely to be examples of a primary hypernephroma-like tumour of the thyroid, and a diagnosis of 'Hürthle-cell' tumour

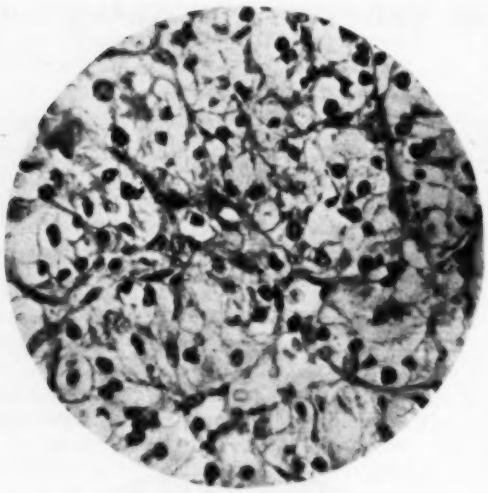


FIG. 303.—*Case* 1 (A.R.I. 988/45). Structure of tumour is alveolar and cells are large, possessing a clear cytoplasm. (× 215.)

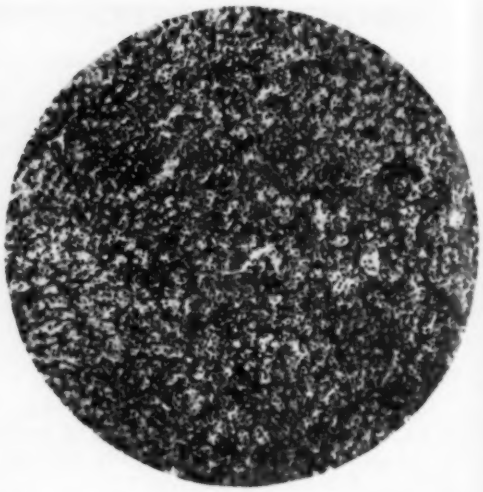


FIG. 304.—*Case* 1 (A.R.I. 848/32). Renal carcinoma (hypernephroma). (× 50.)

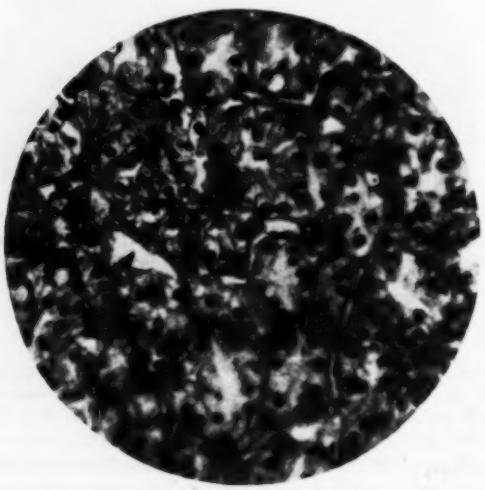


FIG. 305.—Same as *Fig.* 304. (× 215.)

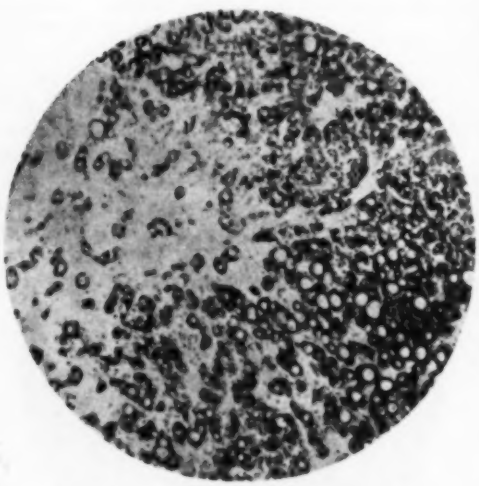


FIG. 306.—*Case* 1 (A.R.I. 988/45). 'Fœtal adenoma' of thyroid. (× 50.)

FIG. 307.—*Case* 1 (P.M. 355/51). Encapsulated metastatic nodule of renal carcinoma in right lobe of thyroid. (× 50.)

FIG. 308.—*Case* 1 (P.M. 355/51). Encapsulated metastatic nodule of renal carcinoma in pancreas. (× 50.)

was rendered, despite the demonstrations of abundant lipoid in the cytoplasm of the tumour cells. This misinterpretation was encouraged by the fact that the sixth nodule proved to be a fœtal adenoma of the thyroid (*Fig.* 306). Meanwhile, no clinical information had been received about the patient's previous history, but subsequent inquiry elicited the fact that a nephrectomy had been performed in 1932. The close histological resemblance of renal (*Figs.* 304, 305) and thyroid (*Figs.* 302, 303) tumours admitted no reasonable doubt that the five opaque nodules in the thyroid were, in fact, metastases of the renal carcinoma.

In 1949 she was re-admitted to hospital with breathlessness and stridor, and with bilateral cervical swellings. Bronchoscopy showed that the tracheal wall was infiltrated by growth, and she was treated with deep X-ray therapy, 2200 r in eleven treatments. The tumour diminished in size, her dyspnœa became less, and she remained in comparative comfort until July, 1951, when she was admitted with a hæmatemesis from a duodenal ulcer which persisted despite transfusion with ten pints of blood. A partial gastrectomy controlled her hæmatemesis, but she died seventeen days later with bilateral pulmonary collapse and right heart failure.

At post-mortem (P.M. 355/51), the relevant findings were: large tumour mass overlying the anterior aspect of the head of the pancreas and filling the concavity of the duodenal loop, single tumour nodule in the right adrenal, multiple subpleural nodules in both lungs, and enlargement of the right lobe of the thyroid by a mass of tumour tissue. The metastatic tumours of the right lobe of the thyroid and in the head of the pancreas are illustrated in *Figs.* 307 and 308 respectively. They conform to the pattern of a renal carcinoma.

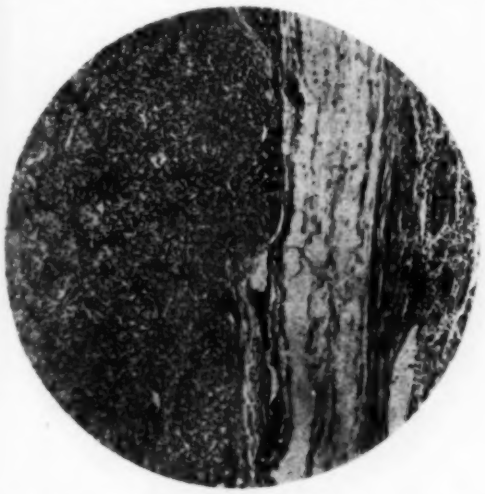


FIG. 310.—*Case* 2 (A.R.I. 2281/46). Encapsulated margin of primary tumour of kidney. (× 50.)

*Case* 2.—(A.R.I. 2281/46 : A.R.I. 1799/49 : Reg. No. 944/53.)

M. S., a woman aged 48, was admitted to hospital in November, 1946, with right lower abdominal discomfort which simulated renal colic and which was associated with considerable vomiting. Prior to admission she had no symptoms referable to her abdomen or urinary tract. Examination showed a well-nourished fit woman, whose pulse-rate was 86, blood-pressure 130/85, blood-urea 48 mg. per cent, hæmoglobin 84 per cent, and red-cell count 4·8 millions. Differential count and blood-film were normal. Tenderness was found in the right abdomen, and in the loin a mass was felt which was considered retroperitoneal. The urine contained a trace of protein, scanty pus, but no red cells. Retrograde pyelography revealed a large tumour distorting the lower calix of the renal pelvis. At operation a tumour was found involving the lower pole of the right kidney, with numerous vessels coursing over its surface. The tumour had invaded the renal vein, but nephrectomy was carried out with ligation of the renal vein proximal to the tumour extension.

FIG. 309.—*Case* 2 (A.R.I. 2281/46). Bisected right kidney showing rounded tumour, 8 × 7 × 6 cm., in lower pole.

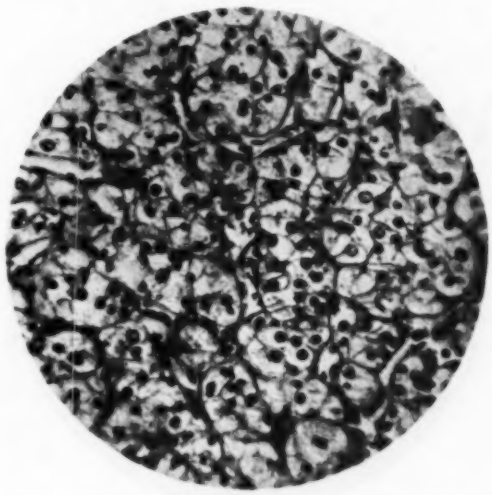


FIG. 311.—*Case* 2 (A.R.I. 2281/46). Structure of tumour is alveolar and cells are large, possessing clear cytoplasm. (× 215.)

PATHOLOGICAL REPORT (Professor J. S. Young).—The *right kidney* (A.R.I. 2281/46) contained a rounded tumour, 8 × 7 × 6 cm., in its lower pole, producing distortion and upward displacement of the renal pelvis (*Fig.* 309). Although apparently encapsulated in this plane of section, two discrete nodules of tumour tissue were recognized outside the capsule in another plane within the substance of the renal parenchyma in the upper pole of the organ. Microscopically (*Figs.* 310, 311) the tumour presented the characteristic appearances of a renal carcinoma (hypernephroma).

In November, 1949, she returned with a cervical swelling which she stated had been increasing for two years. Her pulse-rate was 68, blood-pressure 132/86,

hæmoglobin 90 per cent, and her red-cell count 4·6 millions. She had increased in weight since nephrectomy, and showed no evidence of thyrotoxicosis. Clinical examination suggested a carcinoma of the thyroid. At operation the infrahyoid muscles, found adherent to the gland surface, were left attached. Following division of the superior poles, and the ligation of the inferior thyroid arteries, the recurrent laryngeal nerves were exposed and subtotal thyroidectomy was carried out, leaving less than 1 g. of thyroid tissue on either side. The anterior wall of the trachea was partly infiltrated, and separation was effected by sharp dissection only.

Post-operatively a course of deep X-ray therapy w given in dosage of 2000 r in two fields. She remain symptom-free until August, 1953, when she was admitte with a sudden attack of breathlessness. For a time seemed she might have left ventricular failure due coronary infarction, but it soon became apparent th she had a tracheal obstruction. Her general healt remained good, with a hæmoglobin of 93 per cent. Her white-cell count was 5800, blood-sedimentation rate 58 mm. in the first hour and her basal metabolic rate 18 per cent. Chest radiography showed atelectasis of the left lower lobe. At bronchoscopy two large polypoid masses were removed, the first immediately distal to the vocal cords, the second from the left main bronchus. Symptomatic cure followed the removal of these polyps in which the essential pathological picture was the presence of tumour tissue below a stratified squamous epithelium. The tumour element was vascular and œdematous, but the clear-cell pattern distinctly showed that the polyps were secondary deposits of a renal carcinoma (*Figs.* 314, 315). At present she appears in average health, but recent examination suggests recurrence in the right renal area, and in the right lower neck.

FIG. 312.—*Case* 2 (A.R.I. 1799/49). Encapsulated margin of metastatic renal carcinoma in thyroid. (× 50.)

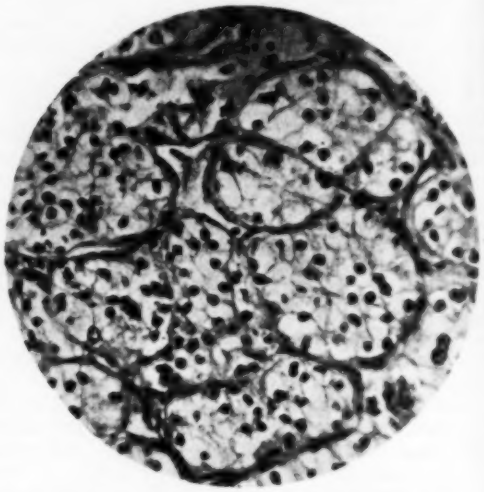


FIG. 313.—*Case* 2 (A.R.I. 1799/49). Metastatic renal carcinoma in thyroid. (× 215.)

FIG. 314.—*Case* 2 (Reg. No. 944/53). Polypoid metastatic renal carcinoma in mucosa of left bronchus. (× 50.)

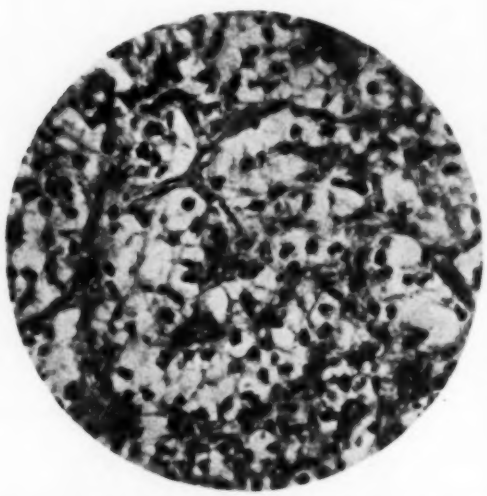


FIG. 315.—*Case* 2 (Reg. No. 944/53). Same as *Fig.* 313. (× 215.)

PATHOLOGICAL REPORT (Professor J. S. Young).—A portion of *thyroid* (A.R.I. 1799/49) was received containing a single encapsulated yellowish nodule of tumour tissue. A complete transection of the tumour, invested by a fibrous capsule and surrounded by normal thyroid tissue, measured 2·5 × 1·5 cm. in the stained section. Microscopically, the tumour (*Figs.* 312, 313) resembled a renal carcinoma so closely, not only in its structure but also in the abundant lipoid content of its cells, that a possible diagnosis of ' Hürthle-cell ' tumour was dismissed in favour of a metastatic hypernephroma.

*Table I.*—Summary of Cases

| Case | Author(s) | Year | Sex | Age | Primary Kidney | Incidence | Operation | B.M.R. | Thyrotoxic Symptoms | Renal History | Pathology of Parent Thyroid | Autopsy Findings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Lubarsch | 1894 | M. | 53 | L. | | | | Emaciation and dyspnœa | | Several deposits dispersed through gland: parent tissue described as normal | Multiple secondaries in abdomen and mediastinum |
| 2 | Kodzubowski | 1904 | | | L. | | | | | | Multiple secondaries in gland | Multiple secondaries: one in right kidney |
| 3 | Barjon and Japiot | 1912 | F. | 75 | R. | | | | Cachexia, palpitation, and gross dyspnœa | | Old adenomatous goitre weighing 250 g. | Large primary in right kidney weighing 280 g. |
| 4 | Rost | 1912 | M. | 48 | R. | | | | Palpitation and cachexia | Hæmaturia 4 wk. before death | Large goitre suggestive of Hashimoto's disease | Pathological fracture of clavicle |
| 5 | Pistocchi | 1922 | | | R. and L. | | | | | | Deposits in both lobes of thyroid | Bilateral hypernephroma |
| 6 | Klose | (*a*) 1925 | M. | 44 | L. | | | | Severe palpitation and exophthalmos | Hæmaturia and renal colic | Histological picture of active primary thyrotoxicosis | Primary in left kidney |
| 7 | | (*b*) 1925 | M. | 52 | R. | | | | | Hæmaturia | | Primary in right kidney: mediastinal secondaries |
| 8 | Willis | 1931 | M. | 73 | L. | | | | | | Fibrotic and with parenchymatous change | |
| 9 | Pemberton and Bennett | (*a*) 1934 | M. | 71 | R. and L. | 2-45,421 | Thyroidectomy | +8 | Weight loss 20 lb.; breathing restricted | | Bilateral hypernephroma | Died 24 hr. after operation: multiple secondaries |
| 10 | | (*b*) 1934 | F. | 35 | L. | ditto | Thyroidectomy | −6 | Palpitation | Subsequent left nephrectomy | Colloid goitre | Survived until 1943 |
| 11 | H'Doubler | (*a*) 1936 | M. | 59 | L. | | Thyroidectomy | +46 | Typically thyrotoxic for 3 yr. | Subsequent left nephrectomy | | Died 3 yr. later with generalized metastases |
| 12 | | (*b*) 1936 | F. | 73 | R. | | Thyroidectomy | | | Right nephrectomy 6 yr. earlier | | Died 4 yr. later with generalized metastases in liver, pancreas, and left kidney |
| 13 | Caylor and Caylor | 1936 | M. | 59 | R. | | Found inoperable | −15 | | Right nephrectomy 13 yr. earlier | Biopsy only, showed secondary hypernephroma, Grade 2 (Broders) | |
| 14 | Weiskittel | 1937 | M. | 60 | R. | 1-10,000 | Thyroidectomy | +32 | | Right nephrectomy 8 yr. earlier | | Died 9 mth. later |
| 15 | Fey and Truffert | 1938 | M. | 55 | R. | | | | | Hæmaturia for 4 wk. | Adenoma of thyroid removed 17 yr. previously | Generalized metastases |
| 16 | Welti and Huguenin | 1939 | | | | | Found inoperable | ±0 | Mildly toxic | Nephrectomy 13 yr. earlier | | Generalized metastases |
| 17 | Black and Long | 1945 | M. | 59 | | 3-50,000 | Thyroidectomy | ±0 | | Nephrectomy 10 yr. earlier | Diffusely enlarged, four to five times normal size with multiple deposits | |
| 18 | Linton and others | 1946 | M. | 55 | L. | 1-10,000 | Thyroidectomy | −3 | Fatigue and loss of weight | Nephrectomy 9 yr. earlier | Diffusely enlarged with nodules up to 2 cm. diameter in a brownish firm gland | |
| 19 | Boys | 1947 | M. | 38 | L. | 1-1702 | Thyroidectomy | +21 | Right vocal cord paresis | | Enlarged, with picture of an old colloid goitre with encapsulated hypernephromatous deposits | Died 5 d. later: primary in left adrenal cortex: sole secondary deposit in thyroid |
| 20 | Moore and Walker | 1950 | M. | 67 | L. | | Thyroidectomy | −18 | Rapid increase in size of gland | Nephrectomy 6 mth. later | Large cysts partly filled with colloid | Died 2 yr. later with generalized metastases |
| 21 | Beahrs and others | (*a*) 1953 | M. | 53 | L. | 5-100,000 | Found inoperable | −7 | Diminished uptake of radio-active iodine | | Biopsy showed deposits in a nodular goitre | Died 18 mth. later with generalized metastases |
| 22 | | (*b*) 1953 | M. | 66 | L. | ditto | Thyroidectomy | +24 | | Nephrectomy 7 yr. earlier | Large adenomatous goitre | |
| 23 | Bruce and Michie (Present cases) | (*a*) 1954 | F. | 60 | R. | 2-1600 | Thyroidectomy | −3 | | Nephrectomy 13 yr. earlier | Multiple secondaries with in addition an encapsulated fœtal adenoma | Died 6 yr. later following gastrectomy for hæmatemesis: generalized metastases |
| 24 | | (*b*) 1954 | F. | 48 | R. | ditto | Thyroidectomy | −18 | | Nephrectomy 3 yr. earlier | Single metastatic nodule invested by fibrous tissue, and surrounded by normal thyroid | |

## DISCUSSION

Perusal of the world literature revealed a total of 22 cases (*see Table I*) of secondary hypernephromatous involvement of the thyroid. In this series the incidence of hypernephroma was equal in right and left kidneys, although in the cases of Pistocchi (1922), and Pemberton and Bennett (1934), both kidneys were said to show primary tumours. Several autopsies of old-standing cases, however, showed later involvement of the remaining kidney, and it is possible that in each case a secondary renal implant had already occurred. Beilin and Neiman (1942), on the other hand, favour the idea of bilateral primary growths, and suggested that direct metastasis from one kidney to the other is unusual. Of recorded cases, commencing with Lubarsch's original record in 1894, the first 7 cases came from Continental clinics, the remainder with the exception of the case described by Fey and Truffert (1938) were from American sources. To date no case has been recorded in British literature, and the only reference has been by Riches, Griffiths, and Thackray (1951), who in a survey of 2314 hypernephromas collected from 67 centres in the British Isles, tabluated 5 secondary hypernephromatous deposits in the thyroid. Of these, 3 were found at routine post-mortem examination.

Statistical analysis of available records (*see Table I*), showed a preponderance of 16 males to 5 females. Though in direct contrast with the sex ratio in thyroidectomy, this was in accord with the incidence of hypernephroma, for which most recorded series give a preponderance ranging between 3 : 2 and 5 : 1 (Willis, 1948), though the records of this hospital show that of 48 cases in the past fifteen years, 23 have been in females. The average age in females was 58, and in males 57, suggesting that the thyroids involved were in the age group of the old and degenerative colloid goitres. From the records, toxicity could be judged to be severe to moderate in 6 cases, mild to non-toxic in 11 cases, with incomplete detail in 7 cases. The histology of the parent thyroid was adequately described in 14 cases, but was lacking in 10. Of the 14 cases, only 2 were stated to be normal; in 4 the histology was that of a colloid, in 3 of an adenomatous, goitre. In 3 cases also, parenchymatous changes were present, and 1 case had the histology of a primary thyrotoxicosis, while in Rost's case (1912), the description conformed to that of Hashimoto's disease. Several reviewers (Pistocchi, 1922; Willis, 1948; Mayo and Schlicke, 1941; Linton, Barney, Moorman, and Lerman, 1946) emphasized the pathological changes in the parent gland as being the basis for the establishment of a secondary deposit.

In the earlier cases the diagnosis of secondary hypernephroma of the thyroid was in the main from autopsy; while from 1934 onwards, 15 cases were diagnosed at thyroid operation. Of these cases, 3 were subjected to nephrectomy after discovery of the nature of the thyroid lesion, while 9 had had a previous nephrectomy for renal carcinoma at intervals varying from three to thirteen years, and with an average of nine years for the series. In 15 cases post-mortem findings were given in detail, and in only 1 case (Boys, 1947) was the thyroid deposit the sole discovered secondary, the patient dying after thyroidectomy. In the remaining 14 cases metastases were generalized, and although the time interval of nine years between nephrectomy and autopsy confirmed the hypernephroma as a slowly growing tumour, the opinion that it may be attended by a single and solitary metastatic deposit was not borne out by autopsy findings.

The relative infrequency of thyroid involvement remains unexplained; both extrinsic and intrinsic factors may play a part. Of extrinsic factors, the filtering action of the lung bed in removing tumour emboli from the systemic circulation is perhaps the most important. The escape of malignant cells into the arterial system was until recently attributed to pulmonary arteriovenous fistulæ, or to the by-pass effect of congenital heart defects; but the work of Batson (1940) postulating a third or vertebral system of veins independent of caval or portal channels, may explain why the vast capillary network of the lung does not extract all emboli. Of intrinsic factors there may be several. Paget (1889) urged that certain organs may be liable to secondary cancer. "When a plant goes to seed, its seeds are carried in all directions; but they can only live and grow if they fall on congenial soil." In a recent publication Cameron (1954) elaborated Paget's soil theory, offering several hypotheses in its consideration. These included the oxygen supply and nutrition of the parent organ, the function of the reticulo-endothelial system as a defence mechanism, and the possible effect of metabolites or secretory products formed in the tissues by tumour cells which might modify their growth. Warburg (1930) pointed out that malignant cells have a relatively anaerobic metabolism, and that highly vascular tissues such as thyroid and spleen do not favour secondary malignant growth; while poorly oxygenated tissues like liver are metabolically favourable for their propagation. It is therefore perhaps not without significance that secondary deposits have more frequently occurred in demonstrably abnormal thyroid tissue, for adenomatous and other degenerative changes result in atrophy of the thyroid parenchyma, and its replacement by relatively avascular thyroid tissue. Willis, in turn, postulated that chemical factors help to explain the scarcity of metastatic lesions of the thyroid, the inhibiting factor being the iodine-rich colloid of the normal gland.

## SUMMARY

1. Two cases of metastatic hypernephroma (renal carcinoma) of the thyroid are described.

2. A summary is presented of 22 cases previously reported in the literature.

3. The rarity of metastatic lesions in the thyroid and the factors which might occasion it are discussed.

We are indebted to Professor J. S. Young for pathological reports, plates of specimens, and for his detailed photomicrography.

## REFERENCES

BARJON and JAPIOT (1912), *Lyon méd.*, **118**, 886.
BATSON, O. V. (1940), *Ann. Surg.*, **112**, 138.
BEAHRS, O. H., GINSBERG, R. L., and MILLER, G. E. (1953), *Proc. Mayo Clin.*, **28**, 205.

BEILIN, L. M., and NEIMAN, B. H. (1942), *J. Urol.*, **48**, 575.
BOYS, C. E. (1947), *J. int. Coll. Surg.*, **10**, 323.
CAMERON, G. R. (1954), *Brit. med. J.*, **1**, 347.
CAYLOR, H. D., and CAYLOR, T. E. (1936), *Urol. cutan. Rev.*, **40**, 576.
FEY, B., and TRUFFERT, B. (1938), *Mém. Acad. Chir.*, **64**, 448.
H'DOUBLER, F. T. (1936), Medical Papers – Christian Birthday Volume, 791. Baltimore: Waverly Press.
KLOSE, H. (1925), *Arch. klin. Chir.*, **134**, 439.
KODZUBOWSKI (1904), *Inaug. Diss., Zürich.* Quoted by KLOSE.
LINTON, R. R., BARNEY, J. D., MOORMAN, H. D., and LERMAN, J. (1946), *Surg. Gynec. Obstet.*, **83**, 493.
LONG, G. C., and BLACK, B. M. (1945), *Proc. Mayo Clin.*, **20**, 43.
LUBARSCH, O. (1894), *Virchow's Arch.*, **135**, 149.
MAYO, C. W., and SCHLICKE, C. P. (1941), *Amer. J. Path.*, **17**, 283.
MOORE, G. E., and WALKER, W. W. (1950), *Surgery*, **27**, 929.
PAGET, S. (1889), *Lancet*, **1**, 571.
PEMBERTON, J. de J., and BENNETT, R. J. (1934), *Surg. Clin. N. Amer.*, **14**, 593.
PISTOCCHI, G. (1922), *Tumori*, **9**, 135.
RICE, C. O. (1934), *Amer. J. Path.*, **10**, 407.
RICHES, E. W., GRIFFITHS, I. H., and THACKRAY, A. C. (1951), *Brit. J. Urol.*, **23**, 297.
ROST, F., (1912), *Virchow's Arch.*, **208**, 53.
WARBURG, O. (1930), *The Metabolism of Tumours.* London: Constable.
WEISKITTEL, R. J. J. (1937), *J. Med., Cincinnati*, **17**, 562.
WELTI, H., and HUGUENIN, R. (1939), *West. J. Surg.*, **47**, 10.
WILLIS, R. A. (1931), *Amer. J. Path.*, **7**, 187.
— — (1948), *Pathology of Tumours.* London: Butterworth & Co.

# GRANULOMA SILICOTICUM CAUSED BY KAOLIN POULTICE

BY GEORGE ARMITAGE AND IRVINE SMITH, LEEDS

GRANULOMA SILICOTICUM (pseudotuberculoma silicoticum) is an uncommon skin lesion nearly always caused by silicates introduced during road accidents. We can find no record of kaolin causing this lesion in man, and the following case is therefore presented.

## CASE REPORT

Mrs. I. M., aged 31 years (251299), attended on Feb. 27, 1953, complaining of a lump in each breast. These lumps had both appeared in the first week of December, 1952, and each had grown steadily causing little pain. Ten years previously, following her first confinement on Nov. 23, 1943, difficult breast feeding had led to engorgement and bilateral breast abscesses. These had been treated at home with kaolin poultices. She received neither surgical incision nor medical attention and the abscesses burst, discharging "a lot of matter" through "very large holes", which did not heal for two or three weeks. She cannot remember how long kaolin was continued after the abscesses discharged, but is quite certain that the lumps appeared at the site where the abscesses had pointed. After a second confinement in 1945 breast feeding lasted four weeks, but the obstetrician noted nothing unusual in the breasts. In 1951 an attack of acute nephritis caused albuminuria for three months; otherwise she has always been well.

Examination showed a healthy woman with well-developed breasts. A lump measuring 3 × 2 × 0·5 cm. was present in the right breast, 1 cm. from the nipple, lying just under the skin, which was intimately fixed to it, being puckered and scarred at this point. The lump was hard and slightly tender and did not extend deeply into mammary tissue, having a fairly discrete edge and an irregular outline. A similar lesion in the left breast was 7 cm. from the nipple and rather larger, showing scarring of the adherent overlying skin, which later became discoloured (*Fig.* 316). Axillary nodes were not enlarged and there was no other skin lesion.

On March 9, 1953, the right lesion was excised under local anæsthesia and Dr. D. H. Collins reported:—

"*Naked Eye.*—A biopsy mass of breast tissue about 2·5 cm. in long diameter with overlying skin showing the edge of nipple areola. Within the dermis is a mass of firm creamy tissue.

"*Histology.*—Foreign-body granuloma of the dermis showing a pronounced pseudo-tuberculous formation, wherein colonies of epithelioid cells, including many foreign-body giant cells are separated one from another by fibrous strands. Doubly refracting crystalline plates and needles are contained within some of the cells and

FIG. 316.—Lesion in the left breast.

giant cells. The epithelial breast tissue is undisturbed." (*Fig.* 317.)

The other lesion was excised on April 18, 1953, and showed similar histological appearances when examined with crossed polarizing prisms (*Fig.* 318).

## DISCUSSION

The evil effect which silica produces in the lung is well known, though not all cases of pulmonary silicosis develop the rapidly progressive fibrosis which is so fatal (Fletcher, 1948).

The talc granuloma (talc sarcoid) is another manifestation of the body's reaction to silica, introduced in this case as magnesium silicate in talcum powder from surgeon's gloves. Since it was first described by Antopol (1933) many papers

have appeared condemning its too frequent occurrence (Eisman, Seelig, and Womack, 1947), for it is preventable and should never occur. Although extensive peritoneal adhesions appear very early after talc contamination (Mackey, 1948), the large granulomata do not appear until nine or ten years later. They may involve any viscus, particularly the Fallopian tubes (Roberts, 1947) and may cause sterility, intestinal obstruction, persistent fæcal fistula, and even death (Swingle, 1948), and have also caused trouble in orthopædic (Key and Ramsey, 1950) and thoracic (Ross and Lubitz, 1949) surgery.

FIG. 317.—Histology of granuloma silicoticum from the right breast with polarizing prisms crossed at 0°, 70°, and 90° respectively. (× 92.)

*Pseudotuberculoma silicoticum* is the name which was given by Shattock in 1916 to the lesion produced by siliceous foreign bodies in the skin. His original case is so typical that it is again described here.

A youth fell from his bicycle and injured his lip on the road. Eleven years later a lump began to grow on the lip and was excised. Histologically this resembled a typical tuberculoma, but no organism could be demonstrated and examination with polarized light showed optically active crystals in the giant cells.

Stewart (1920) showed that cholesterol crystals, old suture material, and a wide variety of artificially introduced foreign particles may be optically active, but proof finally incriminating silica as the cause of this lesion was established by Faulds (1935), who demonstrated the geological identity of fragments of slate from a granuloma silicoticum with slate from the site of the patient's accident twenty-three years previously. Kettle (1932) injected various dusts under the skin of mice. Those containing silica produced typical granulomata, whereas non-siliceous dusts did not. Moreover, if the silica particles were covered by a layer of ferric oxide before injection, no granuloma appeared. A suspension of kaolin (aluminum silicate) produced these granulomata in mice, but kaolin does not appear to have been recorded as producing the lesion in man. The present case demonstrates one more disadvantage of the old-fashioned use of kaolin poultices on septic lesions.

Three aspects of these granulomata suggest that it is an allergic phenomenon following sensitization to silica; these are: (1) The histological picture; (2) Its rarity compared with the frequency of skin injuries caused by silica; (3) The long interval between injury and the appearance of the lump—in particular, in this case the simultaneous appearance of two lumps after such an interval.

## SUMMARY

1. A case of granuloma silicoticum caused by a kaolin poultice is described.

2. The pathology of granuloma silicoticum is discussed.

3. The simultaneous appearance of two lesions nine years after injury is considered as further evidence that this granuloma is an allergic phenomenon following sensitization to silica.

FIG. 318.—Histology of lesion from the left breast with prisms crossed at 60° and 90° respectively. (× 92.)

Since this paper was written Potts (1953) has described kaolin contamination of infected breast and sacral lesions with granuloma formation and failure to heal. Though histologically similar, these lesions are quite different clinically from the granulomatous swelling which develops late in a wound long since healed, as originally described by Shattock.

We are indebted to Dr. J. T. Ingram for his helpful advice. We thank Mr. Blackledge and Mr. Pegg, of the Leeds University Photographic Department, for the photomicrographs and coloured illustration; also Miss E. Hanson and Mrs. K. Milnes for secretarial assistance.

REFERENCES

ANTOPOL, W. (1933), *Arch. Path.*, **16**, 326.
EISMAN, B., SEELIG, M. G., and WOMACK, N. A. (1947), *Ann. Surg.*, **126**, 820.
FAULDS, J. S. (1935), *J. Path. Bact.*, **41**, 129.
FLETCHER, C. M. (1948), *Brit. med. J.*, **1**, 1065.
KETTLE, E. H. (1932), *J. Path. Bact.*, **35**, 395.
KEY, J. A., and RAMSEY, R. H. (1950), *J. Bone Jt Surg.*, **32A**, 815.
MACKEY, W. A. (1948), *Brit. med. J.*, **1**, 1077.
POTTS, E. R., (1953), *Brit. J. Surg.*, **41**, 295.
ROBERTS, G. B. S. (1947), *Brit. J. Surg.*, **34**, 417.
ROSS, W. B., and LUBITZ, J. M. (1949), *Ann. Surg.*, **130**, 100.
SHATTOCK, S. G. (1916), *Proc. R. Soc. Med.*, **10** (Path. sect.), 9.
STEWART, M. J. (1920), *Brit. med. J.*, **1**, 663.
SWINGLE, A. J. (1948), *Ann. Surg.*, **128**, 144.

# ILEOVESICAL FISTULA

## A REVIEW OF THE LITERATURE AND REPORT OF A CASE

By W. R. BLACK
SURGEON, WESTON-SUPER-MARE GENERAL HOSPITAL
AND D. E. BOLT
LATE REGISTRAR, WESTON-SUPER-MARE GENERAL HOSPITAL

THE recent paper by Robinson (1953) describing 4 cases of ileovesical fistula, 3 due to Crohn's disease, has led us to record our own experiences with a similar case and to seek for examples of the same condition in the literature. In fact, the recorded cases of ileovesical fistula are surprisingly few, but of those in which the pathology is stated, a high proportion appear to have been due to Crohn's disease.

Parham and Hume (1909) made an extensive review of the literature of vesico-intestinal fistula, drawing many of their cases from Harrison Cripps (1888), Chavannaz (1897), and Pascal (1900), but adding 38 cases of their own. They gave a detailed table of the cases, their site and pathology, and amongst these we found the site stated in 278 cases, of which 15 were ileovesical (including 3 multiple fistulæ). In this series, therefore, 5·4 per cent of the vesico-intestinal fistulæ were ileovesical, rather less than in the series of Chavannaz, in which they were 7·4 per cent of the total 95.

Apart from Sutton (1921), who was concerned with vesico-sigmoid fistulæ, and Albano (1926), there

is little further reference to the subject until Higgins (1936) reviewed the literature and added a further 35 vesico-intestinal fistulæ from the Cleveland Clinic, his series including no ileovesical fistulæ. In the reported discussion on this paper, however, J. F. Balch recorded 19 cases of vesico-intestinal fistula, of which 3 were ileovesical, 2 due to operative trauma, and 1 to a Meckel's diverticulum. All these 3 cases

FIG. 319.—Barium meal. Note Kantor's string sign and Stierling's sign.

FIG. 320.—Cystogram showing radio-opaque fluid in the bladder and entering a loop of ileum through the fistulous opening.

died. In the next year di Maio (1937) reported 2 fistulæ, of which 1 case was ileovesical and due to ileocæcal tuberculosis.

In 1938, Kellogg, who did not appear to have seen Higgins's paper, was able to analyse 87 cases of vesico-intestinal fistula in detail, from the literature, of which 8 were ileovesical, 3 traumatic, 2 complicating ileocæcal tuberculosis, and 2 multiple fistulæ (1 after irradiation of a carcinoma of cervix and 1 due to a pelvic abscess of uncertain aetiology). In the same year Hall (1938) reported an ileovesical fistula in a man with two years' history of diarrhœa but only two weeks' urinary symptoms. The histology was that of ileocæcal tuberculosis, but there was little evidence of caseation and no other tuberculous focus, so that a diagnosis of Crohn's disease is not impossible.

Mayo and Miller (1940) recorded no ileovesical fistula among their intestinovesical cases, but Forbes (1940) reported 5 fistulæ, of which 3 were ileovesical and all due to Crohn's disease. Ewell and Jackson (1941) had 1 ileovesical fistula among 11 intestinovesical cases, but did not give the cause. Barnes and Hill in 1942 and 1947 discussed 31 cases of vesico-intestinal fistula and mentioned 1 case of ileovesical fistula which was due to Crohn's disease. Lazarus and Marks (1943) reported 5 cases of actual or incipient vesico-intestinal fistula, of which the only ileovesical case was due to Crohn's disease, but Sabeti (1946) recorded an ileovesicocolic fistula from diverticulitis. The only ileovesical case among 25 vesico-intestinal fistulæ reported by Ormond, Best, and Klinger (1949) was due to carcinoma of bladder, while papers by Mayo and Blunt (1950) and Conroy (1951) included no further examples of ileovesical fistula.

In the period reviewed, therefore, there were 481 vesico-intestinal fistulæ recorded in sufficient detail to analyse, and of these 41 were ileovesical, if we include several with multiple fistulæ, and the percentage of ileovesical fistulæ was therefore 8·5. In 30 of the ileovesical cases the pathology was clearly stated and of these 9 were due to Crohn's disease, making 30 per cent. If we add the 4 cases said to be due to ileocæcal tuberculosis, several of which, like that of Hall (1938) sound suspiciously like Crohn's disease, the percentage due to this cause rises to 43.

## CASE REPORT

Mr. J. H., 31 years old, a married man, was first seen in Out-patients on April 30, 1952, and was admitted to hospital on May 22. For nine months he had had occasional stabbing suprapubic pain, and for eight weeks had had continuous pain in the lower abdomen, especially on the right, associated with pain on micturition and urinary frequency, half-hourly by day and from four to six times at night. On May 16 his frequency had become extreme and had culminated in the passage of some reddish-brown material per urethram. Since then his frequency and pain on micturition had improved.

His appetite was good and his bowels were opened twice daily with a rather soft stool but no diarrhœa. He was rapidly losing weight.

His appendix had been removed twenty-one years before.

ON EXAMINATION.—He was pale, with loose skin and slightly furred tongue. His abdomen showed only mild tenderness in the right lower quadrant, but on rectal examination his prostate was found to be tender and slightly enlarged, and to have a soft, hollowed-out area at the centre.

Heart, lungs, and blood-pressure were normal.

Cystoscopy showed only a mild trigonitis.

Urine culture gave a profuse growth of *B. coli*, but repeated investigation showed no acid-fast bacilli.

Excretion pyelography was normal, as was radiography of the chest.

It was concluded that he had had a prostatic abscess, which had discharged spontaneously and, as his symptoms were much improved, he was allowed to go home on May 28, his own doctor being advised on the treatment of his urinary infection.

His progress was followed in Out-patients and his general health and urinary symptoms improved, but, as the urinary infection persisted, he was referred, in July, to a genito-urinary unit, where a full investigation, including cystoscopy, was carried out and our conclusions confirmed.

ON RE-ADMISSION.—By Feb. 13, 1953, his symptoms were worse and he was again admitted to hospital. At that time he had hourly frequency by day, and twice by night, with terminal dysuria and occasional passage of purulent material per urethram. But his abdominal pain had become more severe in the previous six weeks and was now sometimes central, colicky, and associated with vomiting. He had had no diarrhœa, but was continuing to lose weight. His physical signs had not materially changed.

We now concluded that he might well be a case of Crohn's disease, with an incipient fistula, and a barium meal was performed. Follow-through showed a pronounced 'string-sign' in the lower ileum (*Fig.* 319) but no sign of a fistula. Following this, however, he passed what appeared to be barium in his urine and, on the next day, had pneumaturia for the first time. On that day a cystogram was done, which showed a constant deformity of the upper right portion of the bladder, with spill-over of the sodium iodide into bowel, still containing a faint residue of barium (*Fig.* 320).

AT OPERATION.—On Feb. 25 laparotomy was performed via a right para-umbilical incision. The last 8 in. of the ileum were found to be grossly inflamed, thickened, and adherent to bladder, while there were many fleshy glands in the mesentery. Separation of ileum from bladder showed a fistula to be present, admitting only a probe. The hole in the bladder was closed by suture and a right hemicolectomy performed, removing about 12 in. of terminal ileum. A drain from the right paracolic gutter was brought through a stab wound in the right loin, and the rectus sheath was also drained when the abdomen was closed. The bladder was not drained, but the patient passed urine successfully and the bladder gave no trouble.

The patient was discharged on April 2 and in June, 1953, had gained 2 st. in weight and was passing urine three or four times a day and not at all by night. Histology confirmed a diagnosis of Crohn's disease.

## DISCUSSION

It will be seen from this account that our experience agrees with Robinson (1953) that a long period of urinary symptoms precedes both the establishment of a frank ileovesical fistula and the making of a diagnosis accepting a primarily enterological cause for a mainly urinary symptomatology. In this respect the case reported by Hall (1938) was quite different in having two years' history of diarrhœa and developing pneumaturia and a grossly fæcal urine within two weeks of the onset of urinary symptoms. Most of the reported cases, however, seem to have primarily urinary symptoms, a fact which allowed Lazarus and Marks (1943) to diagnose several vesico-intestinal fistulæ while yet 'incipient'.

As so often happens, the less prominent symptoms in our patient might have provided the clue to earlier diagnosis, for his lower abdominal pain and tenderness were difficult to relate to a diagnosis of prostatic abscess, but it was only when abdominal pain became a major complaint that we realized the probable cause. We feel, from our experience with this case, the accounts in the literature, and reflection on the relatively gradual pathological process which must precede frank fistula formation that pneumaturia and a fæcal urine represent a relatively late stage in a process, which might be diagnosed earlier if an intestinal investigation were carried out on more unexplained and resistant cases of cystitis.

## SUMMARY

1. The literature of vesico-intestinal fistula is reviewed, with particular reference to the incidence and pathology of ileovesical fistula.

2. A case of ileovesical fistula due to Crohn's disease is described.

3. The possibility of earlier diagnosis in such cases is discussed.

Our thanks are due to Mr. Quick of the X-ray Department at Weston-super-Mare General Hospital for radiographs.

## REFERENCES

ALBANO, G. (1926), *Arch. ital. Chir.*, **16**, 133.
BARNES, R. W., and HILL, M. R. (1942), *Calif. West. Med.*, **56**, 350.
— — — — (1947), *J. Amer. med. Ass.*, **133**, 456.
CHAVANNAZ, J. (1897), *Ann. Mal. Org. gén.-urin.*, **15**, 1176.
CONROY, T. F. (1951), *Stan. med. Bull.*, **9**, 30.
CRIPPS, H. (1888), *On Diseases of Rectum and Anus*. Philadelphia: Blakiston, Son & Co.
EWELL, G. H., and JACKSON, J. A. (1941), *J. Urol.*, **46**, 693.
FORBES, R. D. (1940), *Northwest Med.*, **39**, 174.
HALL, E. R. (1938), *Canad. med. Ass. J.*, **38**, 343.
HIGGINS, C. C. (1936), *J. Urol.*, **36**, 694.
KELLOGG, W. A. (1938), *Amer. J. Surg.*, **41**, 136.
LAZARUS, J. A., and MARKS, M. S. (1943), *Amer. J. Surg.*, **59**, 526.
di MAIO, G. (1937), *Osped. maggiore*, **24**, 18.
MAYO, C. W., and BLUNT, C. P. (1950), *Surg. Gynec. Obstet.*, **91**, 612.
— — and MILLER, J. M. (1940), *Arch. Surg., Chicago*, **40**, 897.
ORMOND, J. K., BEST, J. W., and KLINGER, M. E. (1949), *Surg. Gynec. Obstet.*, **89**, 411.
PARHAM, F. W., and HUME, J. (1909), *Ann. Surg.*, **50**, 251.
PASCAL, A. (1900), "Des Fistules vésico-intestinales acquises chez l'Homme et la Femme", *Thèse de Paris*.
ROBINSON, R. H. O. B. (1953), *Brit. J. Urol.*, **25**, 127.
SABETI, A. (1946), *J. Mt Sinai Hosp.*, **13**, 86.
SUTTON, C. D. (1921), *Surg. Gynec. Obstet.*, **32**, 318.

# MALIGNANT TENOSYNOVIOMA (FIBROSARCOMA) WITH TWENTY-THREE YEARS' SURVIVAL

By RONALD G. HENDERSON and R. G. MAIN, Falkirk

Joint and bursal tumours are logically included in the same group as those arising from tendons and tendon-sheaths. Some writers have also included among these tenosynovial neoplasias growths derived from muscle aponeuroses. The synovial surface is formed of cells which are modified connective-tissue cells, but between these surface cells and the ordinary collagen-producing fibroblasts of the surrounding tissue, no sharp line of separation can be drawn (Willis, 1953, a).

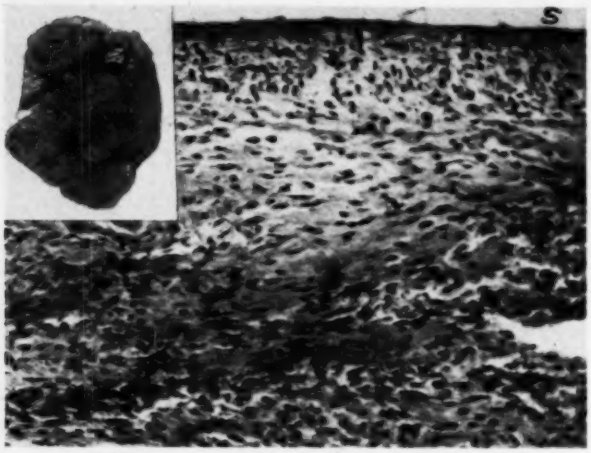



Fig. 321.—A peripheral area of the primary tumour, with synovial surface (S). (× 100.) *The primary tumour*, 1930, actual size, showing definition and lobulated structure.

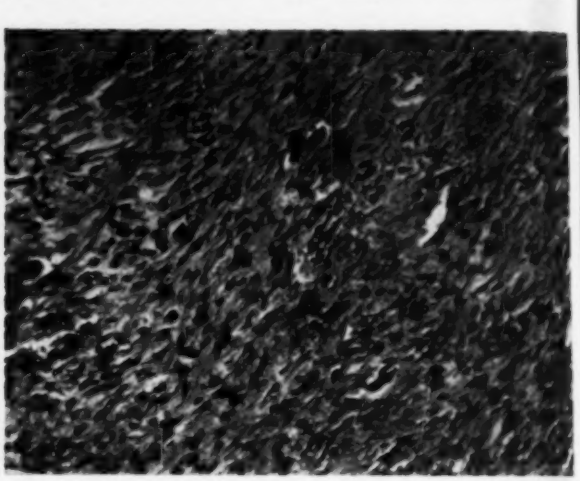


Fig. 322.—A characteristic area, primary tumour, with scattered monstrous cells. (× 100.)

When tumours develop in relation to joints, bursæ, and tendons, it may therefore not be possible to trace exactly the site and tissue of origin, unless the growth is at an early stage. Malignant tumours of these tissues are comparatively rare. They may show a papillary structure with epithelium-like cells lining synovial spaces, or they may be of solid, fibroblastic structure, predominantly spindle-celled with varying degrees of pleomorphism; some tumours show both types of growth. Willis (1953, b) notes that some synovial sarcomas are cured by excision or amputation; others recur or metastasize, usually to the lungs. Boyd (1947) states that these growths are radio-resistant. Prognosis is, in general, unpredictable.

The following case record is thought worthy of presentation because of the unusually long survival after operation of a patient with an initially highly malignant tenosynovial sarcoma.

## CASE REPORT

Mrs. J. R., aged 40, was admitted to Falkirk and District Royal Infirmary in September, 1930, with a hard, elastic swelling in the region of the right biceps femoris tendon which had been present for two months. It suggested a tumour of the fascia, possibly malignant, and was excised.

The tumour (*Fig.* 321, *inset*) was lobulated, non-encapsulated, but well-defined against the surrounding tissues, which included some muscle and a few hyperplastic, benign synovial villi. Microscopically, the tumour consisted of malignant fibroblastic tissue, much of it with a regular, spindle-cell structure and a fibrillary or hyaline matrix (*Fig.* 321). Many parts showed considerable pleomorphism, with monstrous cells of irregular size and shape (*Figs* 322–324). These cellular areas were interspersed between loosely or sparsely cellular zones of tendinous or mucinoid appearance. Little definite mucin production was demonstrable, though some intracellular mucin was suggested in scattered cells, as at x in *Fig.* 323, which shows a typical pleomorphic area. A striking feature was the large number of mitoses in all areas, except at the defined periphery, where the underlying active growth merged into a more or less normal synovial surface (*Fig.* 321, s).

*In October*, 1937, the patient was re-admitted with a hard swelling 1–1½ in. in diameter on the anterolateral aspect of the right thigh proximal to the scar of the previous operation. This swelling appeared fixed to the quadriceps tendon but not to the skin. It had been present for about six weeks. A firm gland was noted in the right groin. The tumour was again excised with surrounding tissue.

Microscopically it was again found to be a fibroblastic sarcoma (*Fig.* 325). The growth was fairly well-defined with some lobulation. Tendon tissue was present at the periphery and strands of it ran into the tumour mass with a gradual merging of tendon and tumour tissues more centrally. Parts of the periphery were ill defined, with extension of malignant growth into the attached muscle (*Fig.* 326) and fibro-fatty tissue. The latter showed much perivascular lymphocytic-cell infiltration, an irritative response which may have explained the hyperplasia of the lymph-node palpable in the groin. The tumour showed a structure very similar to that of the primary lesion, a fibroblastic sarcoma, with areas of marked pleomorphism and numerous mitotic figures, many of atypical form.

*In April*, 1945, there was a further recurrence. A swelling under the scar had grown gradually during the previous six to nine months to a size 9 × 6 in. X rays showed no involvement of bone. The patient had noticed some loss of weight and complained of pain

radiating up and down the leg. Excision was again carried out, the following operation notes being entered in the case records: "Anterior vertical incision in right thigh over the swelling. Vastus lateralis retracted laterally, rectus femoris retracted medially and partially split. This showed a large, encapsulated tumour 8 × 4 × 4 in. had been noticed for three months. Wide excision was again carried out, muscle and fat being extensively cauterized. Microscopically, the areas examined showed fibrosarcoma, with round and spindle cells (*Fig.* 328) but less pleomorphism and fewer mitotic figures than the earlier tissues. The tumour area examined was well

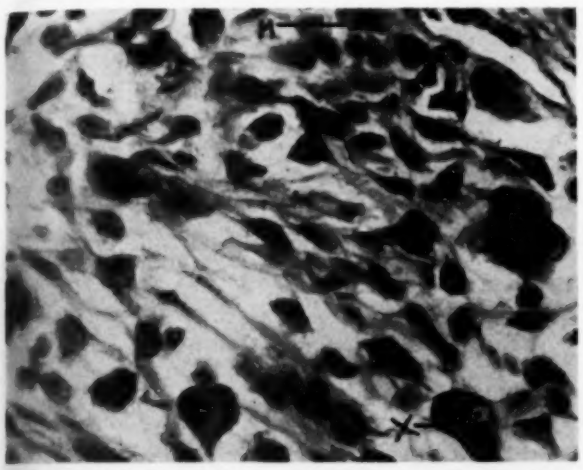


FIG. 323.—A pleomorphic area, primary tumour. M, Mitosis; X, Intracellular mucinoid vacuole. (× 350.)

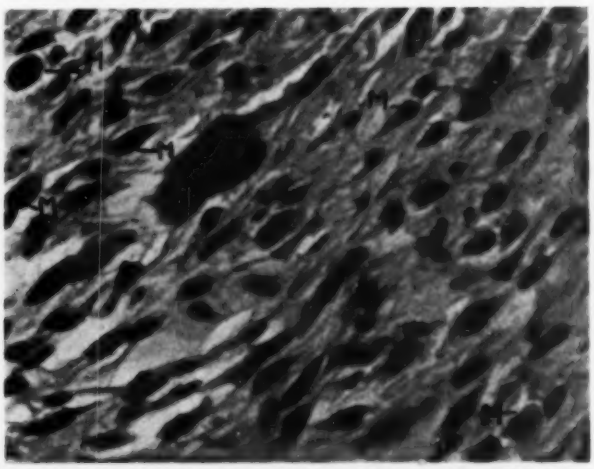


FIG. 324.—Primary tumour, with many mitoses (M). (× 350.)

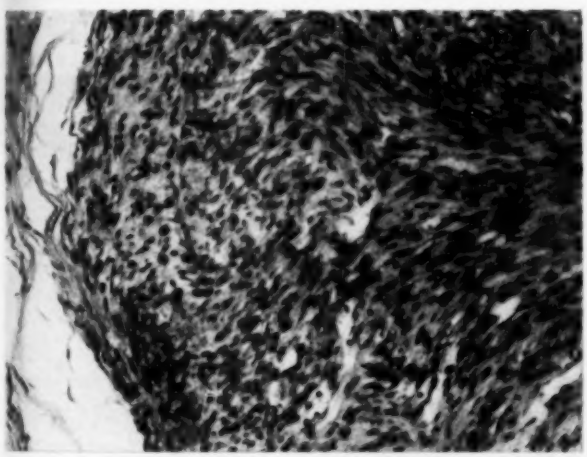


FIG. 325.—*The first recurrence*, 1937, showing well-defined periphery. (× 100.)

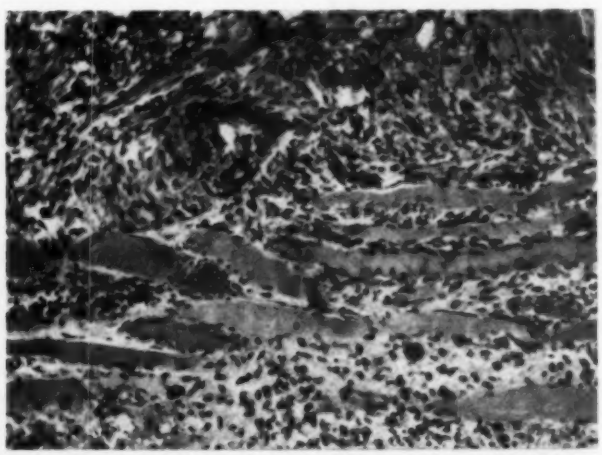


FIG. 326.—Invasion of muscle, first recurrence. (× 100.)

lying under the muscles. It was closely applied to the medial, anterior, and lateral aspects of the femur, but not fixed to periosteum. The tumour was removed and diathermy applied to the muscle surface. The wound was then closed with drainage."

Convalescence was uneventful. On this occasion, the tumour was reported as being a teno-fibrosarcoma, with the observation that the initial lesion removed fifteen years before was probably of tendon origin.

Microscopically, this second recurrence showed again a fibrosarcoma (*Fig.* 327) somewhat lobulated and well-defined in much of its periphery. Broad bands of tendon tissue were present in and around the cellular malignant areas, some of which showed monstrous, bizarre cells. These were, however, less prominent than in the earlier tissues excised, although mitotic figures were easily found. There was much vascularity and perivascular chronic inflammatory cell infiltration.

*In February*, 1946, ten months later, a further, third, recurrence was treated. This time, two swellings had appeared on the lower anterior aspect of the thigh together with several small nodules along the scar. The tumours defined by tendinous tissue against the surrounding fat and again included compressed muscle-fibres. The patient was given two courses of X-ray therapy, the first in April, 1946, two months after this (the fourth) excision, the second in February, 1948.

*In May*, 1948, she was admitted to hospital with another swelling near the right knee; this had developed during the previous month and presented now as a hemispherical lump over the anterolateral aspect of the knee; the overlying skin to which the tumour was attached was cyanosed; the tumour was firm and elastic but with some points of softening in it. The surrounding skin was white and atrophic and adherent to the femur in the line of the most recent scar. On June 8, a mid-thigh amputation of the right leg was carried out. The bone appeared normal at the site of division. In the amputated leg was found a large, hard tumour fixed to skin and bone. Convalescence was again without incident.

The operation tissue of this fourth recurrence showed a glistening, white appearance, firm, elastic, with little obvious vascularity; the cut surface showed fibrous septa with some mottling. Microscopically, in the three

areas sectioned, the tissue showed a fibrosarcoma, as in the primary and previous recurrent growths, but it now looked more malignant, of larger cell structure, with more pleomorphism and more frequent monstrous cells. Mitoses were very numerous and often of highly atypical form. There was abundant tendon tissue—the glistening white appearance noted with the naked eye—which merged gradually into the cellular tumour or, in areas, contained sharply defined tumour deposits (*Fig.* 329). Some parts showed a looser, mucinoid structure, less pleomorphic, but also with numerous mitoses (*Fig.* 330 M).

The patient was last seen at the Infirmary in March, 1953, and perusal of her records revealed the facts above recorded. She is still alive and well. There is to date no sign of recurrence.

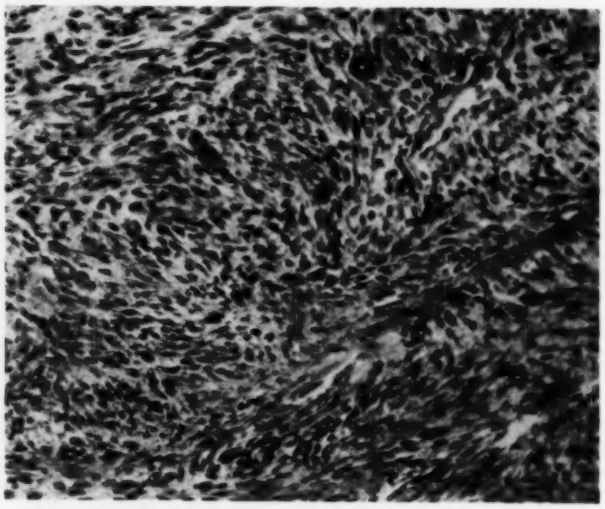


FIG. 327.—*Second recurrence*, 1945, showing similar fasciculated, spindle-cell structure. (× 135.)

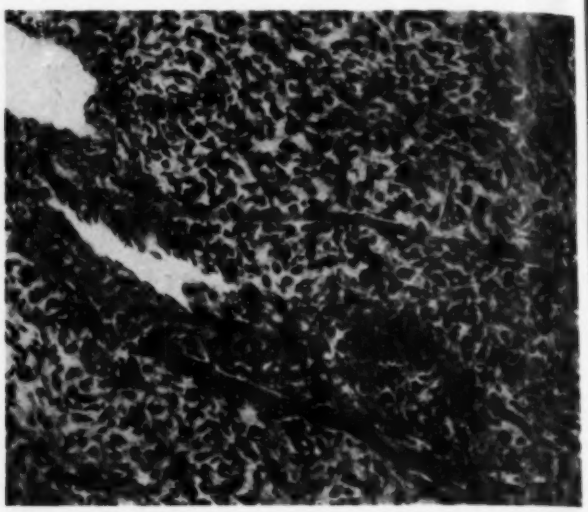


FIG. 328.—*Third recurrence*, 1946, with endothelial-lined clefts and embedded thin muscle-fibres. (× 135.)

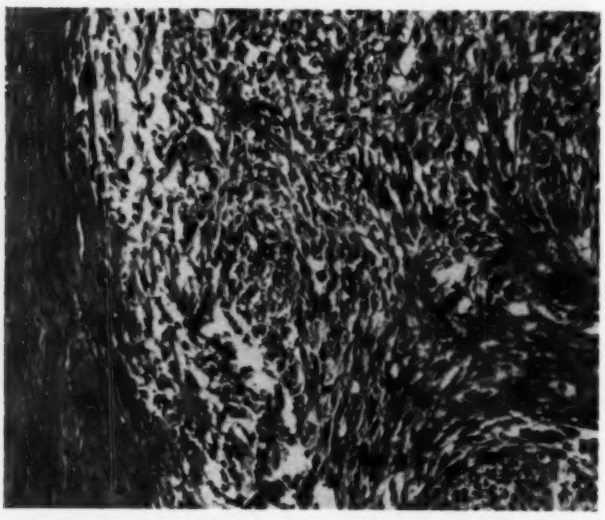


FIG. 329.—*Fourth recurrence*, 1948, showing one of several defined deposits in tendon. (× 100.)

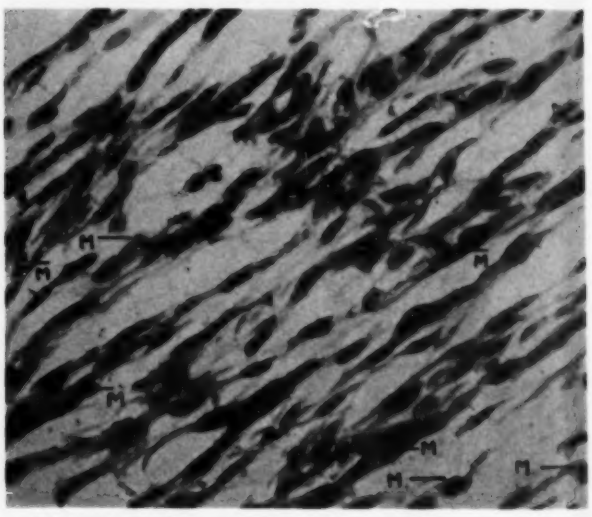



FIG. 330.—Another area of the 1948 tissue, with loose, mucinoid structure and many mitoses (M). (× 300.)

## COMMENT

A chronological summary is presented of the records of a patient who has now survived for nearly twenty-three years with a highly active, repeatedly recurring, sarcomatous tumour of the right thigh. On retrospective histological study of the primary and recurrent growths, the tumour is considered a fibrosarcoma of tenosynovial origin. Though the survival time is remarkable with such an active and pleomorphic tumour, this record may serve as a reminder that prognosis in these cases, though usually unpredictable, is not always unfavourable.

We wish to express our indebtedness to the late Mr. Robert Tennent, who, as Senior Consultant Surgeon, Falkirk and District Royal Infirmary, was responsible for the entire surgical treatment of this case; we would also thank Dr. E. K. Dawson, Royal College of Physicians Laboratory, Edinburgh, for much help and encouragement in the preparation of this paper and for the histological reports.

## REFERENCES

BOYD, W. (1947), *Textbook of Pathology*, 1002. Philadelphia: Lea & Febiger.

WILLIS, R. A. (1953, a), *Pathology of Tumours*, 2nd ed. 693. London: Butterworth.

— — (1953, b), *Ibid.*, 699.

# IRREDUCIBLE INGUINAL HERNIÆ IN CHILDREN

## GANGRENOUS BOWEL IN A 25-DAY-OLD INFANT

By IRVINE SMITH
LEEDS GENERAL INFIRMARY

ALTHOUGH inguinal hernia is the commonest congenital cause of a child's visit to hospital, affecting 5 per cent of all children (Keith, 1924), strangulation in such hernia is less common and gangrene fortunately rare. Gangrene at the age of 25 days must be exceptional. A case in which this occurred and was successfully resected is therefore recorded.

### CASE REPORT

M. L. (265617), aged 25 days, was admitted on Feb. 8, 1953, to the Leeds General Infirmary under the care of Mr. P. J. Moir. He weighed 7½ lb. when born at full term. Breast milk lasted only 14 days, and thereafter half-cream national dried milk had been taken well. The sequence of events on the day of admission was as follows: Whining was noticed during the late afternoon; at his 5.30 p.m. bath a tender lump was seen in the right groin; he vomited his 6.0 p.m. feed and he was admitted to hospital at 8.45 p.m. He was a healthy-looking infant, and had not vomited since 6.0 p.m. T. 99°, P. 120, R. 24. There was a small irreducible right inguinal hernia, with no local redness or œdema. His abdomen was neither distended nor tender. By 9.15 p.m. he had received 1 min. Nepenthe I.M. and was suspended by his legs from the foot of the cot. At 12·45 a.m. (Feb. 9) the hernia was still irreducible.

At 1.30 a.m. under open ether (Dr. J. V. McDermott), operation (I. B. S.) revealed heavily blood-stained effusion and 3 in. of black gangrenous small bowel in the hernial sac which was constricted by the external inguinal ring. After releasing the constricting ring and warming for 7–10 minutes with a hot saline pack, much of this bowel still looked gangrenous; 4 in. of ileum were resected, reconstructing with side-to-side anastomosis (000 catgut). The sac was isolated and closed at its neck.

Feeding by mouth began six hours after operation. Beginning with glucose water, he worked up to 2 oz. full-strength, half-cream national dried milk 2-hourly by the end of the third day and was taking this well. Bowel action started 38 hours after operation. On Feb. 14 he was discharged home with the wound well healed, weight 9 lb., gaining steadily on 4 oz. N.D. 3-hourly, and passing normal stools. On April 1 he was well and gaining further weight (*Fig.* 331).

### REVIEW OF CASES

This case stimulated me to review all irreducible inguinal herniæ in children admitted to the General Infirmary at Leeds during the five years 1948–52. There were 545 uncomplicated and 50 irreducible inguinal herniæ (excluding herniæ met during orchidopexies).

**Sex.**—There were 48 boys and 2 girls.

**Side.**—Thirty-five were on the right, 10 were on the left, in 1 case the side was not stated, and in 2 cases both sides became irreducible. Details of these 2 cases are as follows:—

B. C. (M.) (144859), aged 3 months. Irreducible right inguinal hernia reduced by suspension on March 18, 1950. Right inguinal herniotomy on Oct. 25, 1951. Left inguinal hernia appeared and strangulated on July 9, 1952; reduced by taxis; left inguinal herniotomy on July 10.

M. D. (M.) (143500), aged 10 months. Right inguinal hernia irreducible for 56 hours, reduced and repaired by operation on April 1, 1951. Left inguinal hernia appeared and became irreducible April 17; reduced by suspension; left inguinal herniotomy on May 10. Recurrent right inguinal hernia repaired on Jan. 25, 1952.

**Age.**—Age distribution is shown in *Fig.* 332 and *Table I.*

1. Cases of uncomplicated hernia come for treatment most commonly under 4 years old, but may do so with decreasing incidence right up to the age of 12 years.

FIG. 331.—Infant 7 weeks after resecting bowel.

2. Irreducibility occurs most commonly at a still younger age. Of irreducible cases, 30 per cent were under 3 months, 60 per cent were under 12 months, and 85 per cent under 3 years old. The youngest cases were aged 14, 25, 28, 34, and 37 days respectively. A pair of identical twin boys (183289; 218516), aged 10 months, each strangulated on the left side in the same week.

3. In the younger age groups the proportion of herniæ which become irreducible is much higher than in the older age groups (*Table II*). Of all herniæ admitted under 12 months old, 24 per cent

were irreducible. This figure may have been raised by the tendency to postpone the admission of uncomplicated cases till they are weaned.

**Interval between First Appearance and Strangulation.**—In only 10 per cent of this series did the hernia become irreducible at its first appearance. Moreover, in 84 per cent the hernia had already been present for over a month, and in 14 per cent over a year. The incidence of the various intervals between first appearance and irreducibility is shown in *Table III*. It is interesting to consider that if all children's herniæ underwent operation within a month of appearance, the occurrence of irreducibility would be reduced by 84 per cent. One case (235868), aged 3 months, actually became irreducible while wearing a truss.

*Table I.*—Ages of 50 Cases of Irreducible Inguinal Hernia

| Age at Onset of Irreducibility | Under 3 Mth. | 3–6 Mth. | 6–9 Mth. | 9–12 Mth. | 1 Yr. | 2 Yr. | 3 Yr. | 4 Yr. | 5 Yr. | 6 Yr. | 7 Yr. | 8 Yr. | 9 Yr. | 10 Yr. | 11 Yr. | 12 Yr. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of cases | 15 | 4 | 2 | 8 | 7 | 6 | 2 | 3 | 1 | 1 | — | — | — | 1 | — | — |
| | 29 | | | | | | | | | | | | | | | |

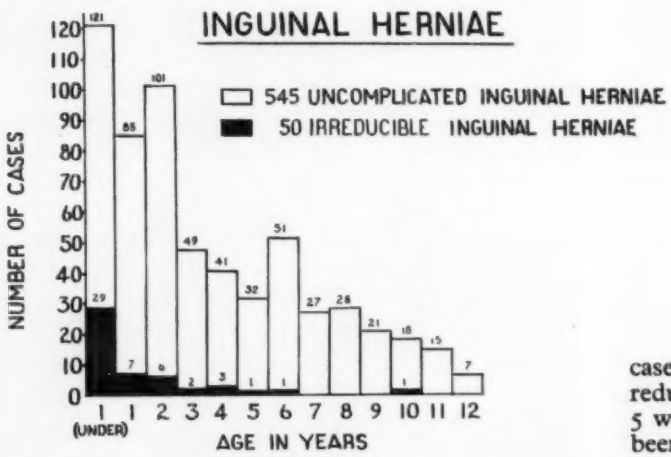



Fig. 332.

**Evidence of Obstruction.**—In 52 per cent of the cases vomiting was noted, but in only 16 per cent of cases was obstruction noted as such. In only 1 case (143500) were distension and visible peristalsis noted, strangulation having lasted 56 hours. Only 1 case (160749) was X-rayed, and this showed distended small bowel with fluid levels after three hours' strangulation.

**Reduction by Taxis** was achieved in 6 cases; all went home without operation and apparently did well.

**Reduction by Suspension.**—Seventeen cases were given sedatives and suspended by their legs from the foot of the bed or a balkan beam ('Solomon position'); 13 of these were reduced, the oldest cases being 24, 23, 18, and 17 months, and the longest pre-treatment delays being 60, 48, 17, and 12 hours. No complication of reduction by this method was recorded, though irreducibility recurred at a later date once in one case, and twice in another case (185988). In 4 cases suspension failed to reduce the hernia. Their ages were 25 days, 5 weeks, 21 months, and 5 years, the herniæ having been irreducible before treatment for 4 hours, 7 hours, 3 days, and 3 hours respectively. Duration of irreducibility before starting treatment is thus no guide to the likely success or failure of this method of treatment.

*Table II.*—Percentage of all Herniæ which become Irreducible in each Age Group

| Age | Total No. of Cases | No. of Irreducible Cases | Percentage Irreducibility |
|---|---|---|---|
| 0–1 yr. | 121 | 29 | 24·0 |
| 1–2 yr. | 85 | 7 | 8·2 |
| 2–3 yr. | 101 | 6 | 6·0 |
| 3–4 yr. | 49 | 2 | 4·2 |
| 4–5 yr. | 41 | 3 | 7·3 |
| 5–6 yr. | 32 | 1 | 3·0 |

**Reduction during Anæsthesia** occurred in only 1 of the 4 cases in which suspension had failed, but in 13 (50 per cent) out of 26 cases in which operation had been selected as primary treatment. In no case was operation deferred.

*Table III.*—Intervals between First Appearance and Strangulation

| Interval between First Appearance and Strangulation | Nil | 1 Wk. | 1 Mth. | 3 Mth. | 6 Mth. | 1 Yr. | Over 1 Yr. | Not Specified |
|---|---|---|---|---|---|---|---|---|
| No. of cases | 5 | 3 | 7 | 8 | 4 | 6 | 7 | 10 |

**Operative Findings.**—Thirty cases underwent operation. The site of constriction was recorded too infrequently to be of value. The bowel was gangrenous in 2 cases (265617, aged 25 days, irreducible 8 hours; and 164150, aged 3 years, irreducible 24 hours). It was strangulated and just viable in 1 case (143550, aged 10 months, irreducible 58 hours) and strangulated but obviously viable in 11 cases, including the youngest case, aged 14 days (25369). In 16 cases the condition of the bowel

was not described. One hernia contained small bowel, appendix, cæcum, and much ascending colon, all strangulated. One case (237909) had strangulation of the testicle, said to be due to torsion, though the state of the cord at the external ring was not noted. Neither female underwent operation (47367, 238020) so the contents of their sacs remain unknown.

**Mortality.**—Only 1 case died (mortality 2 per cent).

T. T. (M.) (164150), aged 3 years. Left inguinal hernia, irreducible for 24 hours, was treated primarily by operation. Bowel considered viable was replaced, but perforated on the ninth day, causing a fatal generalized peritonitis.

## DISCUSSION

In 1938 Thorndike and Fergusson reviewed 106 irreducible cases and the available literature. They confused nomenclature by defining 'strangulation' to have occurred only when gangrene was present. In common acceptance, 'irreducibility' is obvious, 'strangulation' means impaired circulation (confirmed or excluded only by direct examination), and gangrene (tissue death) may follow unrelieved strangulation. The relative incidence of these complications, also other comparisons between the present series and the Boston series, are shown in *Table IV*.

*Table IV.*—Comparison of Leeds and Boston Figures for Irreducible Herniæ

| | General Infirmary at Leeds, 1948-52 (5 Years) | Boston Children's Hospital, 1927-36 (10 Years) |
|---|---|---|
| Total number of children with hernia | 546 | 1740 |
| Number becoming irreducible | 50 (1 in 11) | 106 (1 in 17) |
| | Per cent | Per cent |
| Right-sided | 74 | 80·2 |
| Male | 96 | 96·0 |
| Success of suspension treatment | 75 | 75·0 |
| Incidence of strangulation | 28 | ? |
| Incidence of gangrene | 4 | 4·7 |
| Mortality | 2 | 2·8 |

Our figures show again the higher incidence of irreducibility (24 per cent) among herniæ in cases under 12 months old, a well-known fact first confirmed in the much smaller series of Potts, Ricker, and Lewis (1950). A good rubber horseshoe truss (Browne, 1952) should therefore be used in an infant waiting for operation to prevent irreducibility whether new or recurrent as occurred occasionally in the present series. In almost half (47 per cent) of the irreducible herniæ undergoing operation, i.e., in 28 per cent of all irreducible cases, the bowel showed definite evidence of strangulation. This is surprising and contrary to the usual teaching; consideration of this 28 per cent incidence of strangulation coupled with the 4 per cent incidence of gangrenous bowel can leave no doubt about the need for more careful observation than these cases usually receive, as emphasized by Denis Browne (1952).

Resection of gangrenous bowel has been reported at the age of 12 days (Herzfeld, 1938), though the outcome was not stated. Successful resection in a gravely ill child, aged 20 days, with 2 days' strangulation, was reported by Adams (1943). A similar case, aged 32 days, was reported by Stern and Jones (1950). Spontaneous cure by cæcal fistula after 10 days' strangulation in a 7-week-old Chinese infant was reported by Stocks (1951). Acute appendicitis in a right inguinal hernia was reported in a 16-day-old infant by Remsen (1912), and there are records of several similar cases under three months old. (McCormack 1944.)

When an infant's hernia strangulates, occasionally the testicle strangulates too; this is probably because the whole cord is intimately related to the sac and becomes constricted with it at the external ring. In females the high incidence of ovaries, tube, and even uterus becoming strangulated has been stressed by Watson (1948) and many others.

It is agreed that taxis should be gentle, but is best avoided, for gangrenous bowel might be replaced. Suspension aided by relaxation from sedatives reduced 75 per cent of cases in each of this and the Boston series. I have never heard of gangrenous bowel being reduced by this method. If, however, there is local redness or œdema which indicate strangulation, I think these conditions make suspension unlikely to succeed; there is then danger from prolonging strangulation, and early operation is advisable. Gross intestinal obstruction also suggests local conditions unfavourable for natural reduction, although delay for rehydration before operation may, of course, be essential. In any case, unsuccessful suspension should never last more than 3–4 hours. In the present series there was no correlation between duration of irreducibility before treatment and the success or failure of suspension.

In an adult I have known gangrenous bowel to become reduced without manipulation under anæsthesia. In infants a separate incision would be necessary to secure and examine bowel so reduced. What, therefore, should be done at operation to exclude gangrene? Manipulation likely to replace suspicious bowel should be avoided, a guess at the state of the bowel may be made through the unopened sac, and the colour of the effusion in an opened and otherwise empty sac should be noted. If there is any suspicion of gangrene the abdomen should be explored. If not, herniotomy without exploration will probably be safe—and " probability is the very guide of life ".

Even if the hernia is reduced without operation and can be satisfactorily controlled by a truss, cold herniotomy is best not deferred until after the first birthday; especially where facilities allow the admission of nursing mothers, earlier operation has much in its favour, for a truss may fail to prevent strangulation.

## SUMMARY

1. A case of gangrenous bowel successfully resected from a strangulated inguinal hernia in a 25-day-old infant is recorded.

2. Fifty irreducible children's inguinal herniæ admitted to the General Infirmary at Leeds in the past five years have been reviewed.

3. Strangulation on the same side in the same week in identical twins aged 10 months is recorded.

4. Under the age of 12 months the probability that an inguinal hernia will become irreducible is 1 in 4—much higher than at any other age.

5. Twenty-eight per cent of all irreducible herniæ showed definite evidence of strangulation of bowel and 4 per cent had gangrenous bowel.

6. Figures for age, sex, irreducibility, gangrene, mortality, etc., in this series are similar to a series from Boston.

I should like to thank Mr. P. J. Moir for permission to publish details of this case, which was treated under his care, and for his kind encouragement with this article; Sister Beeston for her skilful nursing of this baby; and all the surgeons on the staff of this hospital for access to records of the other cases here reviewed.

## REFERENCES

ADAMS, K. J. (1943), *Lancet*, **2**, 605.
BROWNE, D. (1952), *Brit. med. J.*, **2**, 1144.
HERZFELD, G. (1938), *Amer. J. Surg.*, **39**, 422.
KEITH, A. (1924), *Brit. J. Surg.*, **11**, 424.
MCCORMACK, C. J. (1944), *Amer. J. Surg.*, **66**, 116.
POTTS, W. J., RICKER, L. W., and LEWIS, J. E. (1950), *Ann. Surg.*, **132**, 566.
REMSEN, C. M. (1912), *Ibid.*, **56**, 911.
STERN, H. S., and JONES, J. E. (1950), *Amer. J. Surg.*, **79**, 478.
STOCKS, F. E. (1951), *Brit. med. J.*, **1**, 171.
THORNDIKE, A., and FERGUSSON, C. F. (1938), *Amer. J. Surg.*, **39**, 429.
WATSON, L. (1948), *Hernia*, 3rd ed., 274. St. Louis: The C. V. Mosby Co.

# SUBCOSTOSTERNAL HERNIA (HERNIA THROUGH THE FORAMEN OF MORGAGNI)

## REPORT OF A CASE

BY RAYMOND HELSBY AND CHARLES WELLS
SURGICAL PROFESSORIAL UNIT, LIVERPOOL ROYAL INFIRMARY

SUBCOSTOSTERNAL hernia is sufficiently rare to warrant the report of a single case.

## CASE REPORT

M. W., a widow aged 66 years, had been well all her life until eighteen months prior to her admission to hospital when she began to complain of regurgitation of acid fluid into her mouth whenever she lay down. She was advised to sleep propped up on pillows and this symptom immediately subsided. About three months later she experienced some fullness and discomfort in the epigastrium half an hour after taking food, particularly fried food, vegetables, and fruit. These symptoms were relieved by vomiting, which, as time passed, became more and more frequent. The vomitus consisted of undigested food mixed with acid and sometimes bile. The patient had lost 2 st. in weight.

On examination of the abdomen a succussion splash was elicited in the left upper quadrant and there was some tenderness in the right subcostal region. Physical examination was otherwise normal. Clinically, therefore, the case presented as one of pyloric obstruction, and, with no previous history of peptic ulceration, carcinoma of the stomach became a likely diagnosis. This seemed all the more probable since the patient has been known to one of us for more than twenty years and the sudden decline in her well-being was most striking. Fractional test-meal showed an acid curve within normal limits, the aspirate containing neither blood nor bile. Radiography of the chest and a barium meal suggested an eventration of the right leaf of the diaphragm with interposition of stomach and colon between diaphragm and liver (*Fig.* 333).

AT OPERATION.—On July 28, 1953, the abdomen was explored through an upper right paramedian incision. Immediately behind the lower end of the sternum there was a defect in the diaphragm, about 2 in. in diameter. Through this defect a large peritoneal sac extended into the chest. The sac contained the greater part of the stomach, transverse colon, and great omentum (*Fig.* 334). These contents were easily reduced into the abdomen and the sac was then excised and closed at its neck. The defect was repaired by approximating its posterior margin to the posterior rectus sheath with interrupted thread sutures. The gall-bladder was found to contain stones, and cholecystectomy was performed. It was also noted that the œsophageal hiatus was patulous, easily admitting the tips of two fingers.

Post-operative progress was uneventful. Two months after operation the patient reports she is well, can eat anything, and is gaining weight.

## COMMENT

According to Harrington (1941) Morgagni is to be credited with the first description of a hernia of this type in 1769. It was a post-mortem finding in a patient who died from other causes. Essentially it is a direct hernia through a defect, probably congenital, in the attachment of the diaphragm to the sternum and adjacent costal cartilages. For this reason Harrington proposed the term 'subcostosternal hernia'. In 1945 he reported 404 cases of diaphragmatic hernia in which operation was performed. Of these there were only 8 cases of hernia through the foramen of Morgagni.

During the past four years 36 other cases of diaphragmatic hernia have been treated by operation in this unit. Of these, 24 were of the 'sliding' type with a retracted cardia, and 12 were true paraœsophageal herniæ.

Two of Harrington's cases presented with pulmonary symptoms only and were diagnosed clinically and radiologically as primary intrathoracic lesions. At operation the hernial sacs contained omentum. In the others hollow viscera were involved and these patients had symptoms referable to the

gastro-intestinal tract. Saltzstein, Linkner, and Scheinberg (1951) were able to collect only 44 reported cases up to the end of 1949, and to these they added whom were aged 55 or over, the hernial sac contained stomach and colon; only 3 of these were subjected to operation.

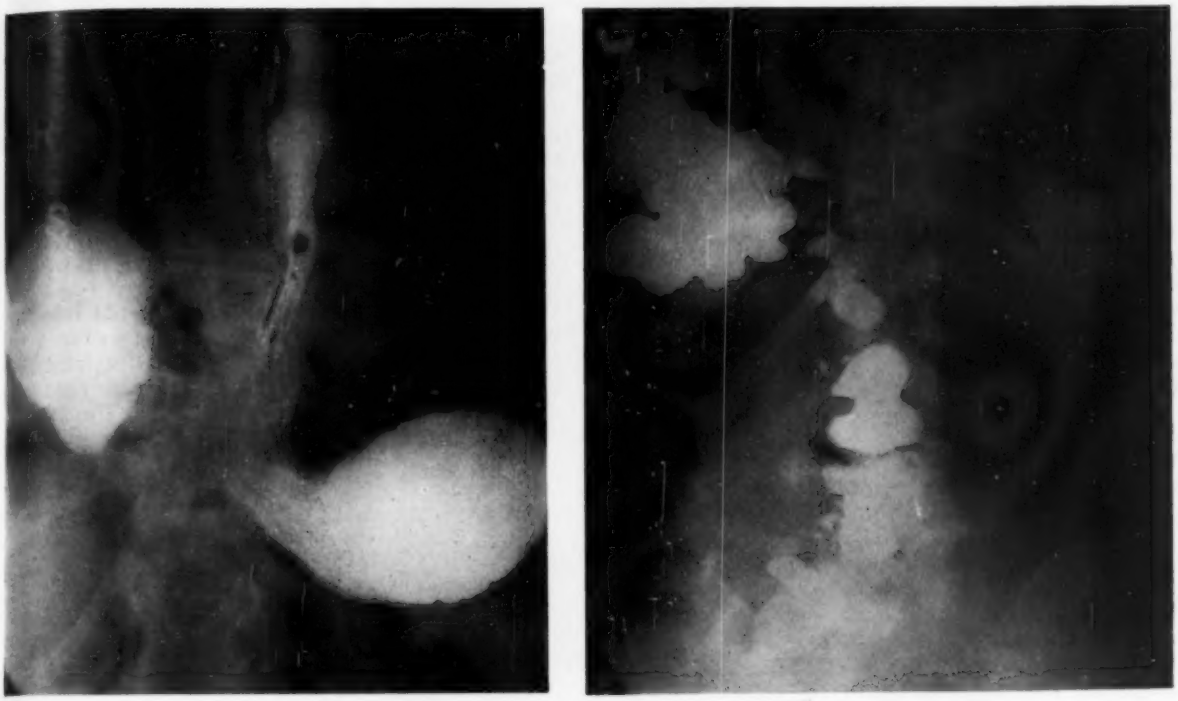


FIG. 333.—Barium meal suggesting interposition of stomach and colon between diaphragm and liver.

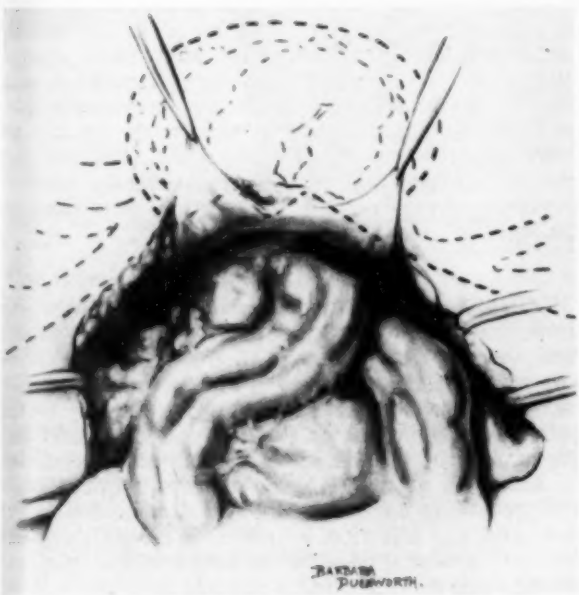


FIG. 334.—Artist's drawing of findings at operation. Dotted lines indicate costal cartilages, and hernial sac and contents.

1 case of their own. Only 21 cases had been subjected to operation. In 33, i.e., three-quarters, of the 45 cases, colon, with or without other viscera, was involved in the hernia. In 7 patients, all of

Since 1949, 2 further cases have been found. Diveley (1950) reported a 39-year-old male who presented with symptoms of pyloric obstruction. At operation colon and omentum were found in the hernial sac. These structures had exerted traction on the pyloric antrum and caused its rotation through 180°. De Nicola and Vracin (1950) reported a child aged 2 years who suffered from repeated abdominal 'cramps' accompanied by coughing attacks with severe cyanosis. At operation the sac contained part of the liver, but no gut. We have found no case report of a subcostosternal hernia in an adult in this country since that of Dunhill (1934).

Finally, it is interesting also to note in our patient the coincidental finding of a lax œsophageal hiatus. This accounts for the initial symptom of acid regurgitation in recumbency. Harrington (1941) described a similar case and was able to find no other in the literature.

## REFERENCES


DE NICOLA, R. R., and VRACIN, D. J. (1950), *J. Pediat.*, **36**, 100.

DIVELEY, W. (1950), *Arch. Surg., Chicago*, **60**, 626.

DUNHILL, T. (1934), *Brit. J. Surg.*, **22**, 475.

HARRINGTON, S. W. (1941), *Surg. Gynec. Obstet.*, **73**, 601.

— — (1945), *Ann. Surg.*, **122**, 546.

SALTZSTEIN, H. C., LINKNER, L. M., and SCHEINBERG, S. R. (1951), *Arch. Surg., Chicago*, **63**, 750.

# VENOGRAPHY AND THE APPROACH TO VARICOSE VEINS

By IAN F. K. MUIR, ERIC H. MUCKLOW, and ANTHONY J. H. RAINS
QUEEN ELIZABETH HOSPITAL, BIRMINGHAM

THE precise nature of the initial derangement in the development of varicose veins is still unknown in spite of the most diligent inquiries. With the discovery of the circulation of the blood, the earlier notion that they were due to an excess of 'crass melancholy blood', was superseded by more mundane mechanical theories. The idea of actual mechanical obstruction was in its turn discarded, and the importance of the venous valves and hydrodynamic factors associated with man's erect posture was realized. The valves of the superficial veins themselves, the deep veins, and the communicating veins have been successively the focus of attention and, while no final conclusive answer has been reached, it is generally accepted at the present time that the primary defect lies in the communicating veins which become incompetent, thus throwing a greater strain on the unsupported superficial veins than their valves can tolerate, so that varicosity ensues.

The use of radio-opaque substances as an aid to the solution of these problems was invoked many years ago and several methods have been evolved. The methods themselves are not of great complexity, and in some countries venography is widely used. It is not, however, our intention to suggest that venography should be used in the routine management of varicose veins. The number of cases that a surgeon (in this country) is called upon to treat is so great as to make such a suggestion impracticable, and furthermore in the majority of cases venography, as we shall show, can give little more information than can be gained by careful clinical examination. As a research technique, however, it is of value in checking the results of physical examination and, furthermore, it may give valuable assistance in certain cases where additional information is required before embarking on a course of treatment.

We wish, therefore, to relate our experiences of venography in over fifty limbs and to describe a simple technique which has given satisfactory results. In patients with varicose veins we shall indicate how the results have compared with the clinical findings, and how they have influenced our choice of surgical treatment. This group will include those cases where there is reason to doubt the integrity of the deep vein.

## METHOD

It is agreed by all workers that injection of the superficial veins directly gives little information of value, as the capacious veins accommodate a large quantity of radio-opaque medium which throws on the radiograph a tortuous confused pattern which is impossible to interpret. Lindblom (1941) and Hellsten (1942), however, showed that if a tourniquet is placed around the ankle, an injection into the superficial veins below it will pass through communicating veins into the deep veins of the foot and ascend from thence to the deep veins of the calf. The deep venous system of the leg will then be delineated on the radiograph. If the communicating veins of the leg (which are normally valved to allow flow inwards only) remain competent, then no medium will pass into the superficial system, but if these communicators are incompetent then outflow will occur and will be obvious on the film. Obstruction of the superficial veins by the tourniquet must of course be efficient, and sclerosis of the veins and induration or œdema of the tissues form practical problems which must be overcome if mistakes in interpretation are to be avoided.

If the patient is horizontal during the injection, clearance from the deep veins may be so rapid that a satisfactory picture may not be obtained, and furthermore, the heavy radio-opaque media at present available may gravitate towards the calf and fail to fill anteriorly placed vessels. Moore (1949) suggested that this difficulty could be overcome by applying a second tourniquet around the thigh to obstruct venous return and then hold the opaque medium in the leg for an indefinite time, making it possible to take at leisure as many exposures as necessary.

We have preferred to get over this difficulty by standing the patient up. In the erect position and at rest the venous return from the lower limbs is small, and the removal of the opaque medium is further slowed down by its high specific gravity, a fact which in itself is a disadvantage, for it means that we cannot say that the behaviour of the medium represents exactly that of the blood in the vessels under similar conditions. No other radio-opaque substance with a specific gravity comparable with that of the blood is available for intravenous use, and until one is discovered this must remain an inherent defect of the method. At least we feel that the method which we use represents the smallest departure possible from the normal conditions in the leg.

## TECHNIQUE

A rubber tourniquet is placed around the leg immediately above the ankle to occlude the superficial veins. The patient is then stood on the foot-rest of the X-ray table which is standing vertical or just short of the vertical plane to give stability to the patient. It is important that the patient should feel adequately supported and this decreases the tendency to faint. A needle (size 14 or 12) mounted on a syringe is then introduced into a suitable vein on the foot, and the injection is made. For the purposes of our investigations we excluded those patients whose veins promised to be difficult to inject, and we took care to have the patient, and particularly the foot, warm. If the veins are difficult to enter with a needle, but it is considered important to have a venogram—as, for instance, in a case of deep vein thrombosis—then, with the patient lying down, a vein on the foot is exposed under local anæsthetic and a fine polythene tube is introduced and tied in. The patient is then stood on the foot-rest of the table as before, with the ankle tourniquet in place.

The injection is made with 20 to 30 c.c. of 35 per cent diodone, which is injected as fast as it will comfortably go through the needle. Sometimes we have used up to 40 c.c. of 35 per cent solution. The 50 per cent solution has not given better results in our hands, and if injected outside the vein tends to be painful. From the time of the injection the patient should remain quite still. Radiographs are now taken in the anteroposterior and lateral planes, using non-screen film. It is important that the foot be in a position of internal rotation in relation to the axis of the tube, so that the deep veins can be seen in the clear space which shows between the bones of the leg, and, at the same time, in the lateral view the deep veins stand out clearly behind the tibia and are not overlapped by the fibula. As a routine the anteroposterior and lateral films are taken to show the lower leg and knee only, but further films can be taken if desired.

This comprises the procedure which we have used generally. In some cases we watched the leg on the X-ray screen during the injection of the diodone and this was always instructive. The dye could be seen passing up the deep veins and spilling out through the incompetent communicators into the superficial varicose system. With this technique 14/14 cassettes were used with screen film and exposures made through a moving grid. Three radiographs were usually taken, one for the distal part of the lower limb, one in the region of the knee, and lastly a film of the thigh, the use of the grid being of considerable advantage in the latter region. In other cases we have tried to make an estimate of the rate of clearance of diodone from the veins after commencement of exercise. This exercise consists of vigorous flexion and extension of the toes. We have used both screening and exposure of films at timed intervals for this. Unfortunately, the high specific gravity of the diodone delays clearance, often in an unusual and irregular manner, and we have therefore not been able to come to any definite conclusion as to what constituted a normal time. On occasions we have seen the diodone cleared rapidly from the superficial and deep circulation, and on a film exposed at 10 seconds after the injection little may be seen. In most cases with clinically normal veins, clearance will be complete at one minute, and if diodone remains after two minutes, we consider this as abnormal. In dilated superficial veins it may remain for very long periods, an indication of the stagnation which occurs.

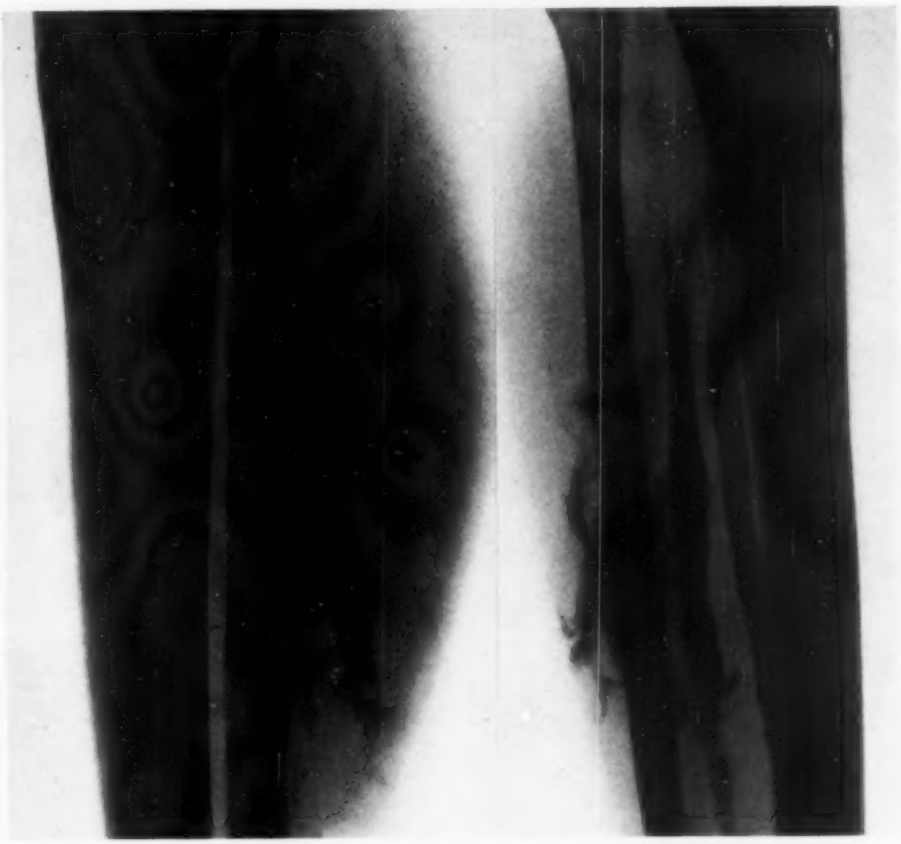


FIG. 335.—Normal venogram (*see* text). Findings, normal.

## FINDINGS

**Normal.**—*Fig.* 335 shows the venogram of a normal volunteer. Filling has occurred of all three deep venous channels and in the lateral view a sheaf of veins running from the calf muscles is shown. Turner Warwick (1931) has stated that these veins are not valved (which would explain their retrograde filling from the main venous trunks), but that

outflow into the superficial veins is prevented by the pinching effect of the muscles. In many of our films no calf muscle veins are shown, and it seems likely that valves do exist in some cases and prevent the dye from filling the vein.

*Fig.* 336 shows the normal distribution of deep veins and valves behind the knee and in the thigh in other normal limbs.

FIG. 336.—Normal venogram (*see* text). Findings, normal.

**Varicose Veins.**—A patient, aged 60, presented at the Out-patient Department with fixed renal pain, and, as an intravenous pyelogram was desired, the opportunity was taken to introduce the dye into the foot and thus obtain a venogram. He had no symptoms referable to his legs, but there were a few tortuous veins in the calf. The venogram (*Fig.* 337) shows a very early stage in the development of varicose veins. The deep veins are well shown, and it is interesting to compare the spacing of valves in the deep and superficial veins. Those in the deep veins are situated closer together and are much more numerous than those in the superficial veins, and in the anteroposterior view this enables one to pick out the short saphenous vein which is superimposed on the posterior tibial and popliteal veins. The sites of two communicators between the posterior tibial and long saphenous vein can be seen (X). Communicators between the long and short saphenous system, a prominent feature in almost all venograms of varicose vein sufferers, are easily seen. The short saphenous vein can be seen turning forward just above the level of the knee-joint to enter the anterior aspect of the popliteal vein (Y). Another interesting point emerges on examining the lower part of the popliteal vein in the anteroposterior and lateral films (the anteroposterior film being exposed first). In the anteroposterior film the vein at this level is greatly narrowed, this constriction forming a smooth hour-glass shape (Z). In the lateral film this part of the vein throws such a faint shadow that it can only be seen by an exercise of imagination, but the vein immediately above, limited by a valve, is full and bulging (Z). This probably represents compression of the vein by local muscular activity with emptying of one segment into another, and, as many workers have pointed out, non-filling of a vein or segment of a vein shown in one picture only cannot be taken as proof of abnormality.

Venograms of patients with a more severe degree of varicosity give an idea of the number of incompetent communicators which one may expect to find in the average case. In general it may be said that the farther down the leg one goes the more frequently will communicating veins occur, but they are not necessarily all found to be incompetent applied here will often give complete control. In other cases, however, there will be evidence of one or a few 'blow outs' at lower levels, and *Fig.* 340 shows such a case. The Trendelenburg test was strongly positive and there was evidence of a single geniculate branch (G.C.) which was confirmed radiologically and at operation.

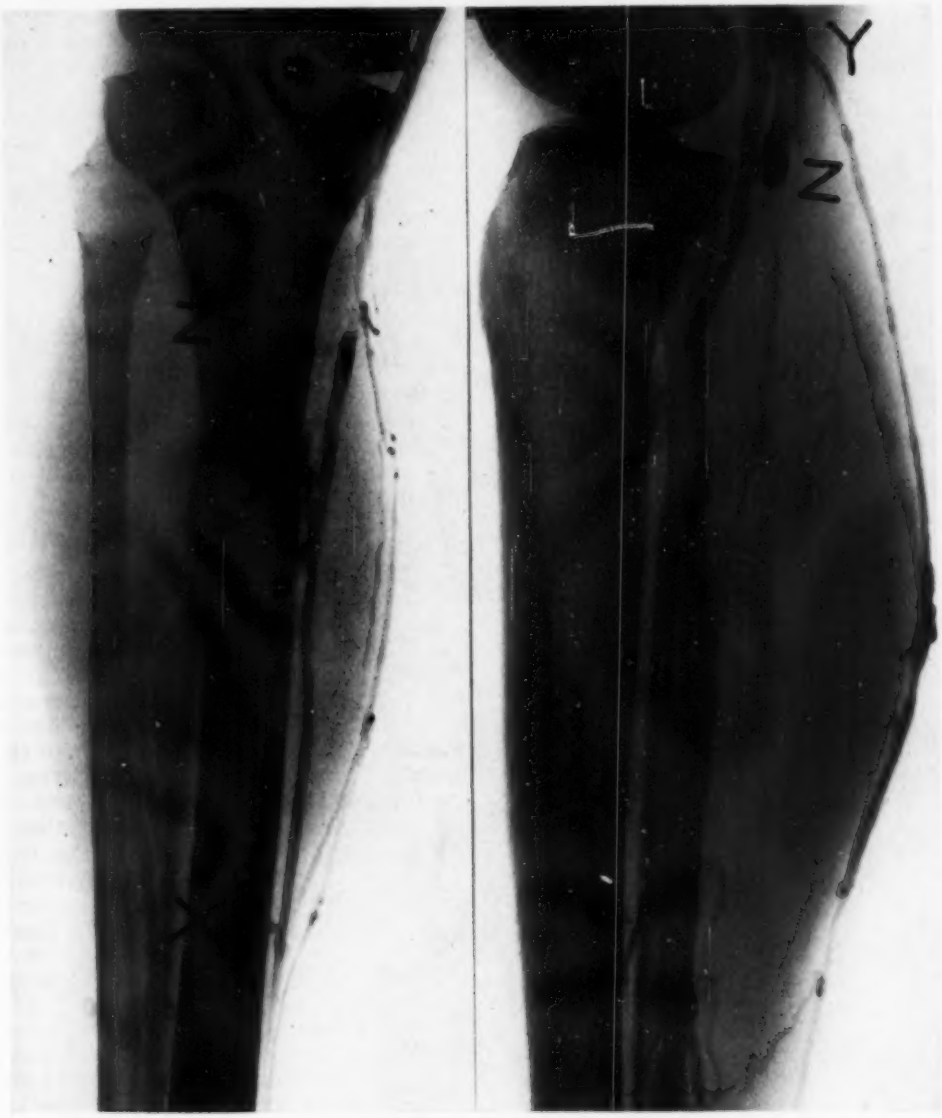



FIG. 337.—Venogram showing very early stage in the development of varicose veins (*see* text). Findings, varicose veins.

(*Fig.* 338). The tributaries of the deep veins in *Fig.* 338 are very suggestive of normal venæ comites. They may be compared with the venæ comites shown in the femoral arteriogram (*Fig.* 339). These venæ comites may merely be draining the muscle masses and not having any possible communication with the superficial system. There is a type of case which we have come to associate with young men with marked varicosity of the whole length of the main trunk of the long saphenous vein but with little involvement of its tributaries. In these cases back-flow from the groin is marked and a thumb

**The Short Saphenous Vein.**—The relative immunity of the short saphenous vein to varicose change is of great interest. In the venogram it shows again and again as a single straight slender structure passing up the back of the calf. The mode of termination is of interest and our venograms show that this is more variable than we had previously thought. In some cases it enters the popliteal vein a short distance above the knee-joint (*Figs.* 336, 337, 340), but in others it enters it higher up at the superior angle of the popliteal space, and sometimes it is very irregular in its termination (*Fig.* 341).

Two important facts go far towards explaining its immunity. Firstly, the termination of the vein and its upper valve are deep to the deep fascia and

FIG. 338.—Venogram showing tributaries of the deep veins (*see* text). Findings, varicose veins.

therefore have the supportive and compressive benefits of the muscles. Secondly, its communicators with the deep veins seem to come only from the muscular branches in the soleus and gastrocnemius, which are themselves so closely supported by muscle that they never become incompetent. The unusual termination of the vein may be another factor in protecting it from abnormal pressures, but, in view of the free communications which exist between it and the long saphenous systems, it still seems remarkable that it does not more often become secondarily involved in varicosity of the latter system.

**Varicose Veins and Old Deep Thrombosis.**—Surgeons sometimes feel hesitant about advising operation on varicose veins in patients who have a history of deep thrombosis. We have investigated five patients who were referred for treatment of varicose veins and who had a clear history of deep thrombosis. We do not intend to discuss the details of the venographic findings in these cases. In those cases where there is a history of deep thrombosis the deep veins should be inspected, and, if present, then an attempt to visualize the valves should be made. The Valsalva manœuvre may aid one in this search. It will suffice to say that in only one patient did we fail to demonstrate that recanalization had occurred. This failure has not yet been accepted as positive proof that the deep veins are not patent, but it may have been due to the dye being absorbed by the large superficial veins. In this particular case venography was repeated with a firm compression elastic bandage applied to the whole limb, but it still failed to show filling of the deep veins, so that we have deferred the question of operation on this leg.

## FINDINGS COMPARED WITH CLINICAL FINDINGS

In general it may be stated that the venographic findings have accorded well with our clinical findings, and confirm the view that incompetence of communicating veins is the immediate cause of varicose veins, so that it is towards these structures that our therapeutic attention should be directed. In the groin and in the thigh the position of the appropriate communicators (i.e., the termination of the long saphenous vein and the mid-Hunter connexion) are constant enough for clinical examination to determine incompetence or otherwise at these sites with confidence, and our venographic studies have been directed more at determining the sites and numbers of deep communications below the knee. A number of clinical tests may be used to locate these. The site of maximum pain is an indication which will occur early in the examination; inspection may suggest a communicator close above a varix, or even, low in the leg, directly deep to it, and on palpation the hole in the deep fascia through which the perforator passes may be felt. In the lower leg they are described as direct and pass from the main deep trunks to the main trunk of the long saphenous vein which they join at right angles. More rarely, and then generally on the outer side of the leg over the anterior muscular compartment, they join a tributary of the main vein. As we have said, Turner Warwick has described indirect communicators from the posterior calf muscle veins to the short saphenous system, but we have not found these in our cases. The higher up the leg the more oblique do the communicators become.

Unless the actual hole in the fascia can be felt, the communicator can be localized only by what is in effect a Trendelenburg's (or Brodie's) test in miniature. The leg is examined repeatedly from

FIG. 339.—Femoral arteriogram showing tributaries of deep veins (*see* text). Findings, varicose veins.

FIG. 340.—Venogram showing incompetent geniculate communicator (G.C.). L.S.V., Long saphenous vein; S.S.V., Short saphenous vein. (*See* text.) Findings, varicose veins.

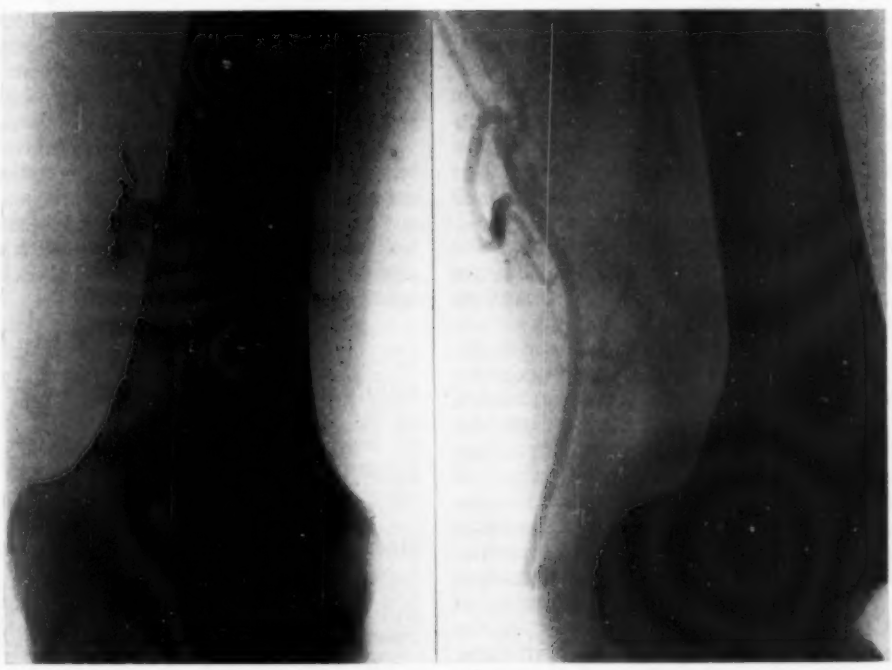


FIG. 341.—Venogram showing irregular termination of the short saphenous vein (*see* text). Findings, the short saphenous vein.

above downwards. After a communicator is localized the vein immediately below it is compressed by a thumb and the veins emptied by elevating the leg. The second thumb now compresses the vein below the first and the patient stands up. While the vein is inspected the lower thumb is removed. The manœuvre is repeated, the upper thumb remaining in its original position, while the second thumb moves progressively down the leg. The interpretation of the test is precisely similar to that of the Trendelenburg test. We have found multiple tourniquet tests to be inaccurate, and prefer this method of double digital compression.

## FINDINGS IN RELATION TO TREATMENT: GENERAL REMARKS

High ligation of the long saphenous vein in the groin remains the most important single step in the operative treatment of varicose veins. If backflow from the femoral to saphenous vein is present, then if high ligation is not carried out no procedure performed lower down can be expected to be of more than transient benefit. Deriving information from Powell and Lynn (1951), valves are likely to exist in the external iliac vein or in the common femoral vein above the sapheno-femoral junction in respectively 30 per cent and 60 per cent of people, so that it is apparent that in these legs the status of the long saphenous vein does not differ from that of the communicators lower in the leg. In about one-fifth of any number of people no valve is present above the sapheno-femoral junction, so that if the highest valve of the long saphenous vein becomes incompetent, the lumen of the vein becomes exposed to all the vagaries of pressure occurring in the great veins, and the importance of an adequate high ligation becomes even greater. In some cases, which may by inference belong to this group, the high ligation may so modify conditions for the better that the symptomatic relief may be completely adequate in spite of the persistence of patent and obvious varicose veins.

A mid-Hunter 'blow-out', if present, can frequently be located with accuracy by the multiple finger test, and it should be noted that in this position the communicator is most frequently found to be rather above the point where finger control is effective, so that the incision should be placed accordingly.

The geniculate communicator can be found and identified with a high degree of certainty, and we believe that in these three positions operative exploration should be performed if indicated.

Below the level of the geniculate communicator conditions differ according to the degree of certainty with which communicators are identified on clinical examination. If a fairly small number can be demonstrated, then individual dissection and ligation is a practicable proposition. Most of them will be what Turner Warwick has called 'direct communicators', which connect directly with the main vein. Sometimes indirect communicators joining branches of the main vein can be located and attacked direct. One practical point about the ligation of these communicators deserves emphasis, for, if the operation is to be of value, then each of them must be found and either ligated and divided without interfering with the main superficial vein, or removed by a T excision which includes both communicator and a length of superficial vein. The latter method is that most frequently employed. If no deep connexion is found, an excision of 1–2 in. of the superficial vein is usually performed *faute de mieux*, but our experience is that collateral channels soon open up to by-pass such an area, and we feel that it is a procedure of doubtful value. One should certainly not set out with the idea of performing this latter operation at set levels of the leg in every case, and the practice of multiple ligations of the veins through short incisions without any attempt to locate incompetent communicators is to be condemned as a waste of time for everyone concerned. It is the practice in this country to perform these ligations on a plane superficial to that of the deep fascia, and we have so far conformed in this, feeling that the subfascial ligations as advised and performed by Linton (1938) means involving the patient in a more major procedure than is indicated, at least in the thigh. The deep fascia in the lower leg, however, is a thin, and in places a tenuous, structure, and recent experience with other operations in this region has made us feel that subfascial ligation of communicators is a more practical proposition than has heretofore been considered.

If, therefore, the communicators are localizable, and if they are few enough in number to make individual dissection feasible, then we believe this to be the method of choice in the surgical treatment of varicose veins, rather than the blunderbuss methods of mass retrograde injection or stripping. If, however, the communicators are very large in number or difficult to locate, then mass injection or stripping must be resorted to. In the majority of cases, the decision can be made on clinical grounds alone, but in cases where doubt is felt as to the proper treatment to advise, then a venogram will well repay the trouble of performing it.

## SUMMARY

This paper relates the experiences of venography in over fifty limbs, and describes a simple technique which has given satisfactory results.

The findings in normal limbs and those with varicose veins are described, together with a short note on deep thrombosis.

In patients with varicose veins it is indicated how the results have compared with clinical findings, and how they have influenced the choice of surgical treatment.

We should like to acknowledge the advice and encouragement of Professor F. A. R. Stammers, the facilities and assistance granted us by Miss La Gallais of the X-ray Department, the clinical photography of Mr. T. F. Dee, and the assistance of Mr. I. J. Cunningham and other volunteers.

## REFERENCES

HELLSTEN, W. O. (1942), *Acta Chir. Scand.*, Supp. 73.
LINDBLOM, K. (1941), *Acta radiol., Stockh.*, **22**, 288.
LINTON, R. R. (1938), *Ann. Surg.*, **107**, 582.
MOORE, H. D. (1949), *Brit. J. Surg.*, **37**, 78.
POWELL, T., and LYNN, R. B. (1951), *Surg. Gynec. Obstet.*, **92**, 453.
WARWICK, H. TURNER (1931), *The Rational Treatment of Varicose Veins and Varicocele.* London: Faber & Faber.

# USE OF LEFT COLON FOR RECONSTRUCTION OF PHARYNX AND ŒSOPHAGUS AFTER PHARYNGECTOMY

By J. C. GOLIGHER and IAN G. ROBIN

FROM ST. MARY'S HOSPITAL, LONDON

One of the least satisfactory chapters in surgery is that which relates to the treatment of carcinoma of the hypopharynx. After even the most extensive excisions, recurrence of the growth is all too common. It would appear indeed that malignant disease of this organ, like that of the œsophagus, is virtually incurable by surgical means, and that as with œsophageal carcinoma, the main objective of surgery must be temporary palliation of symptoms. Since the development of the method of œsophageal resection with immediate restoration of continuity by an intrathoracic œsophagogastric anastomosis, operation for carcinoma of the œsophagus has had a high palliative value, for if the patient survives the operative hazards his dysphagia is instantly and completely relieved. By comparison the palliative effect of radical surgical treatment for carcinoma of the post-cricoid region has until recently been much reduced by the fact that with the classical operative techniques of Trotter (1913) and Wookey (1940), hitherto in vogue, the patient was left with a temporary break in the continuity of his upper alimentary tract. A subsequent plastic operation was thus required to reconstruct the pharynx and restore normal deglutition, and if, as was not infrequently the case, this was not entirely successful in the first instance, it had to be repeated, thus protracting the convalescence. Not till complete pharyngeal closure was secured could the patient be said to be really comfortable. Till then he had to endure the inconveniences of a pharyngostomy and tube feeding. Sometimes, indeed, it has happened that the growth has reasserted itself before pharyngeal reconstruction has been concluded, so that the patient has derived little benefit from surgical treatment and his last few months of life have in fact probably been made more miserable by it.

What is needed in the surgery of pharyngeal carcinoma is an operation that provides for immediate pharyngeal reconstruction and returns to the patient normal deglutition without prolonged hospitalization. Several attempts have been made in recent years to satisfy these requirements, the reconstruction of the pharynx being achieved by the use of a temporary prosthesis of tantalum wire mesh with a covering of fascia lata (Rob and Bateman, 1949) or of a Portex tube surrounded by a Thiersch graft, raw surface outwards (Owen, 1950), or by swinging up flaps of skin from the upper part of the front of the chest (Lewis, 1952). These methods have had their successes, but sometimes troublesome sinuses or stenoses have resulted which have reduced their immediate palliative value. However, it is not our intention in this paper to attempt an evaluation of these techniques. Rather do we wish to describe an alternative approach to the problem of immediate pharyngeal reconstruction after pharyngectomy—namely, the elevation to the upper part of the neck of a mucosa-lined tube from some part of the alimentary tract for direct end-to-end anastomosis with the superior pharyngeal remnant to bring it into communication again with the stomach.

## CHOICE OF VISCUS FOR IMMEDIATE ANASTOMOSIS TO THE UPPER PHARYNGEAL REMNANT AFTER PHARYNGECTOMY

**Stomach.**—Following the demonstration by Sweet (1948) and Garlock (1948) that the stomach could be sufficiently mobilized to permit of an anastomosis being performed in the neck between the cervical œsophagus and the gastric fundus after resection of carcinomata of the upper thoracic or cervical œsophagus, it was but logical to consider the possibility of effecting a pharyngogastrostomy after pharyngectomy. We are prepared to believe that in exceptionally visceroptotic subjects with a very long J-shaped stomach this might be feasible. Our own investigations relating to this manœuvre, however, suggest that it can only rarely be possible. In 4 cases during the operation of resection of high œsophageal growths with cervical œsophagogastrostomy we have tested the possibility of drawing the gastric stump still farther into the neck to the level that would be required for the performance of a pharyngogastrostomy after pharyngectomy. In none of the cases could it be sufficiently elevated for this purpose, and we are therefore of the opinion that only very occasionally could pharyngogastrostomy be the solution to the problem of pharyngeal reconstruction after radical treatment of carcinoma of the pharynx.

**Œsophagus.**—In some respects the gullet would seem to be the natural organ to anastomose to the pharynx after pharyngectomy, but, as it is essential in any radical operation for post-cricoid carcinoma to remove at least 2 in. of œsophagus in addition to the hypopharynx, approximation of the parts by direct suture would only be possible if the entire thoracic œsophagus and upper part of the stomach were thoroughly mobilized and displaced headwards *en bloc*. This would divide all collateral vessels to the œsophagus and leave it entirely dependent on the blood-supply derived from the stomach. We are aware of the experimental work of Parker and Brockington (1949), Swenson and Clatworthy (1949), and Macmanus, Dameron and Payne (1950) demonstrating that in dogs the œsophagus can be mobilized throughout its entire length, without necrosis occurring, and that it may be extensively freed, divided, and anastomosed with a high proportion of successes. However, the œsophagus is a very much more robust structure in the dog than in man, and the vascular anastomoses in its wall are also probably more numerous and effective than in man. Our observations during œsophagectomy would support Sweet's (1946) contention that the human œsophagus cannot be devascularized for any

length without a considerable risk of necrosis. We would be very dubious of the ability of the gastric blood-supply to nourish more than the lowermost 3 or 4 in. of œsophagus. If, therefore, one were to attempt a direct pharyngo-œsophageal anastomosis after pharyngectomy, it would seem better to mobilize the stomach as fully as possible and to displace it upwards into the thorax and neck to the maximum extent, conserving only the most distal part of the œsophagus as a short prolongation of the gastric stump. But the retention of less than 3 or 4 in. of œsophagus is unlikely to be of assistance in prolonging the gastric stump because of the fact that the œsophagogastric junction is not at the summit of the fundus but at the cardia, which in the extended condition of the stomach may be situated several inches lower down. Under the circumstances we think that it would always be more reliable to anastomose the pharynx directly to the fundus of the stomach than to the distal portion of the œsophagus, and for that reason we have not ourselves essayed pharyngo-œsophagostomy after pharyngectomy. We have, however, been interested, and not a little surprised, to read that Wooler (1952) has successfully performed pharyngo-œsophagostomy after pharyngectomy in one case.

**Jejunum.**—The pioneer work of Yudin (1944) on jejunal œsophagoplasty was our initial guide to the prospect of manufacturing a mobile stump of jejunum capable of reaching to the upper cervical region. At the Institut Sklyfossowsky in Moscow, Yudin (1944) had the opportunity of treating many patients suffering from stenosis of the œsophagus due to swallowing of corrosives. In their management he developed the technique of making an antethoracic œsophagus partly out of jejunum, as originally performed by Roux (1907), and partly out of skin-flaps as done by Bircher. In 61 of his 82 cases treated by this technique the jejunal loop could only be made to stretch part of the distance to the neck, and it was necessary to construct a skin-lined tube by a plastic operation on the upper chest and lower part of the neck to prolong the artificial gullet to the cervical œsophagus or pharynx. In the other 21 cases he was able to prepare a sufficiently long stump of jejunum to extend into the upper cervical region to permit of a complete jejunal œsophagoplasty. More recently, Harrison (1949) and Robertson and Sarjeant (1950) have published several cases in which they also were able to take jejunum up into the neck for œsophagojejunostomy with varying degrees of success. The only difference in their technique of œsophagoplasty from that of Yudin (1944) lay in the fact that they utilized the shorter transthoracic route—either the posterior intrapleural or the anterior extrapleural—rather than the presternal subcutaneous route for the transit of the jejunum.

Our experiences with the formation of jejunal loops for cervical œsophagojejunostomy, and those of most of our surgical acquaintances who have attempted this manœuvre, have been much less fortunate. During the operation of total gastrectomy and of œsophagogastrectomy for carcinoma of the stomach or lower œsophagus with œsophagojejunostomy using the Roux type of anastomosis, we have many times experimented to see how long a jejunal stump we could fashion, using the technique described by Yudin (1944) and paying special attention to the incision of the peritoneal leaves of the mesentery on which he lays such stress. Only rarely have we succeeded in preparing a viable jejunal stump to reach beyond the arch of the aorta, and but once have we managed to make it extend above the top of the sternum. Though Yudin was successful in achieving complete œsophageal replacement by jejunum in approximately one-quarter of his cases, we feel that in average hands the proportion of cases in which a sufficiently long loop of jejunum could be prepared for the more extensive pharyngo-œsophageal replacement required after pharyngectomy would always be infinitesimally small.

**Colon.**—Our interest in the use of a segment of colon for œsophagoplasty was first aroused by seeing Dr. Egidi at the San Spirito Hospital in Rome in 1944 successfully prepare an antethoracic œsophagus from transverse colon in a child suffering from a long post-corrosion œsophageal stricture, using the technique originally described by Vulliet (1911), Kelling (quoted by Yudin, 1944), and von Hacker (1914). For this form of œsophagoplasty to be extended to pharyngeal reconstruction a longer piece of bowel would have to be available than is usually provided by transverse colon alone. The possibility of utilizing also the descending and iliac colon in addition to the transverse, was suggested by our experiences in the last two years of high ligation of the inferior mesenteric artery during excision of the rectum (Goligher, 1954). When this artery is tied at its origin from the abdominal aorta in an operation for rectal excision the left colic artery is necessarily sacrificed. Yet in the majority of the cases in which this is done the blood-supply to the descending and iliac colon through the middle colic and marginal artery is sufficient to ensure their viability and to permit of their retention either for the establishment of an iliac colostomy or for an anastomosis to a rectal stump or to the anal region. These observations led us to conclude that in many cases a long colon stump composed of the left two-thirds of the transverse, descending, and upper sigmoid colon could be prepared nourished satisfactorily by the middle colic and marginal artery and suitable for œsophagopharyngoplasty.

On searching the literature we found that the idea of using not only the transverse but the left colon in œsophageal surgery had already occurred to several French surgeons. Thus Orsoni and Toupet (1950), Orsoni (1951), Orsoni and Lemaire (1951), and Rudler (1951) have utilized the left colon to construct an antethoracic short-circuit between the cervical œsophagus and the stomach in œsophageal carcinoma, or occasionally as a preliminary procedure in certain poor-risk subjects with operable growths of the œsophagus. Much was hoped for at first from this device, but further experience has unfortunately revealed a high percentage of unsatisfactory results. An instructive collective review by Rudler (1951) of 28 cases in which the left (or right) colon was used in this way records that there were 8 operative deaths, and that in no less than 13 of the 20 survivors leakage occurred from the œsophagocolic anastomosis with resulting persistent fistula

formation; the anastomosis between the proximal end of the colon and the stomach or jejunum, however, invariably healed without incident.

So far as we could gather, no attempts had hitherto been made to extend this method of colon œsophagoplasty to the pharynx by bringing the colon up to the upper pharyngeal remnant after pharyngectomy, but it appeared to us to offer possibilities of cut. In the same way we hoped that by the time the second stage of mobilization of the colon was performed and the sigmoid was divided below, the supply to the descending and sigmoid colon from the middle colic would be adequate for the nourishment of this long stump of bowel.

We have recently employed a loop of left colon, prepared according to the principle described above,

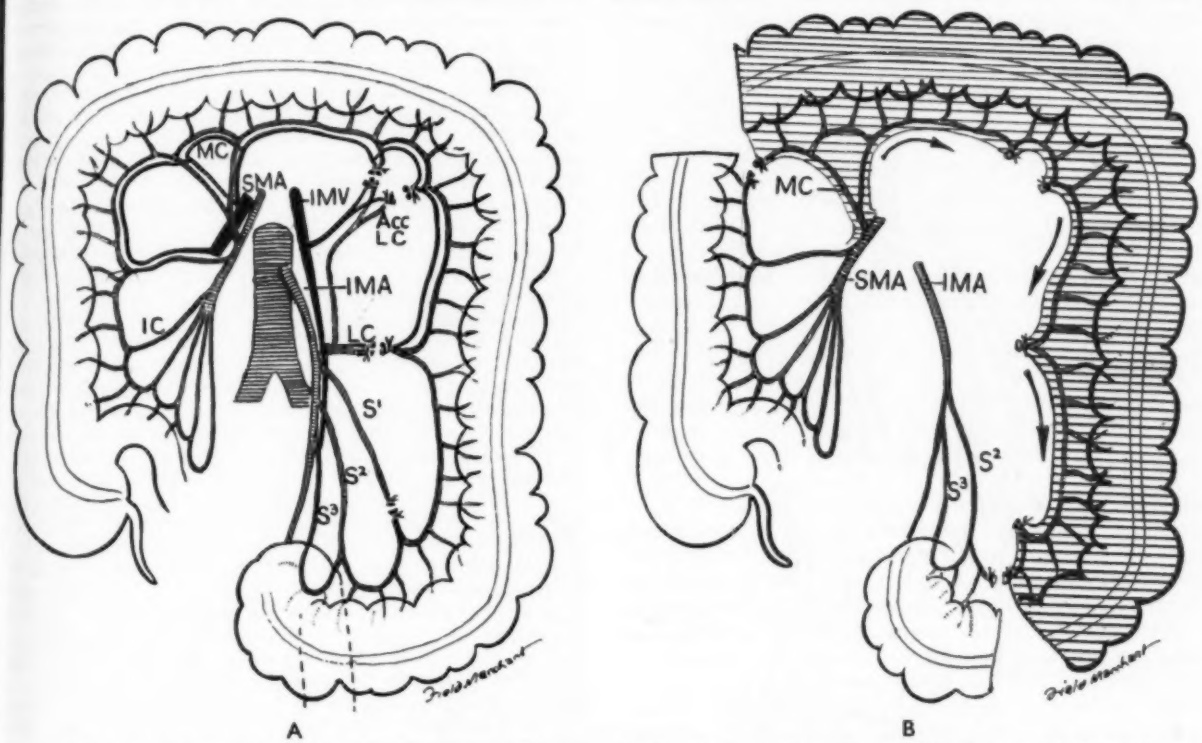



FIG. 342.—Preparation of left colon for use as a replacement for the pharynx and œsophagus. (A) *Stage* I: Ligation and division of left colic (LC), accessory left colic (Acc. LC), and first sigmoid ($S^1$) vessels. (B) *Stage* II: Division of marginal vessels and colon at right end of transverse colon and middle of sigmoid loop, leaving left colon entirely dependent on the middle colic (MC) artery for its blood-supply.

being useful in this way. We appreciated that there might be a risk of necrosis of the cervical end of the colon and of a breakdown of the anastomosis in the neck as in the recorded œsophageal cases, but we thought that this could probably be diminished by the adoption of a two-stage procedure in the preparation of the colonic stump, to improve its blood-supply. The first stage would consist solely of ligation of the left colic, accessory left colic, and first sigmoid arteries (as in *Fig.* 342 A), the second stage, carried out two or three weeks later, of thorough mobilization of the bowel and its division through the junction of the middle and right thirds of the transverse colon above and through the middle of the sigmoid loop below (*see Fig.* 342 B). During the interval between the two stages the blood-supply to the left colon from above and below through the marginal artery would presumably improve to compensate for the cutting off of the supply from the arteries which were ligated, in the same way as the arterial supply to either end of a tube-pedicle skin-graft gradually increases in the two weeks or so following the raising of the tube, so that eventually it is sufficient for the certain maintenance of viability in the tube from one end alone when the other is for immediate reconstruction of the pharynx after pharyngectomy with success, and consider it important to record this solitary case because it establishes the feasibility of this technique.

## CASE REPORT

Mr. E. C. (392694), aged 34.

HISTORY.—For nearly three years the patient had experienced slight intermittent dysphagia on swallowing solid food, which seemed to stick in the lower part of the neck. In September, 1952, his dysphagia increased in severity and he began to lose weight. He reported to St. Mary's Hospital at this stage. Clinical examination was negative. Radiological examination after a barium swallow was performed on Sept. 24, and Dr. T. R. Riley reported as follows: "This patient had no difficulty in the act of swallowing. In the lateral films there is an appreciable narrowing of the hypopharynx from the level of the upper border of the body of C.V. 4 down to about the level of the mid-part of the body of C.V. 6. There never seems to be normal relaxation in this length of the pharynx. When screened in the anterior posterior position the barium stream takes a very definite course to the right at the level mentioned above, owing to the fact that it is displaced by some space-filling lesion in the left side of the pharynx (? arising from the left pyriform fossa region). Whatever this mass may

be I think it should be well visualized on direct endoscopy ".

Repeat pharyngo-œsophagoscopy, however, was still negative and accordingly no active treatment was advised. He was told to attend for periodic review, but as his symptoms subsequently seemed to improve somewhat, he did not report again for several months. Finally in March, 1953, he returned with very severe dysphagia, having recently lost over a stone in weight; he was immediately admitted. Pharyngoscopy now revealed a mass of neoplasm in the post-cricoid region coming

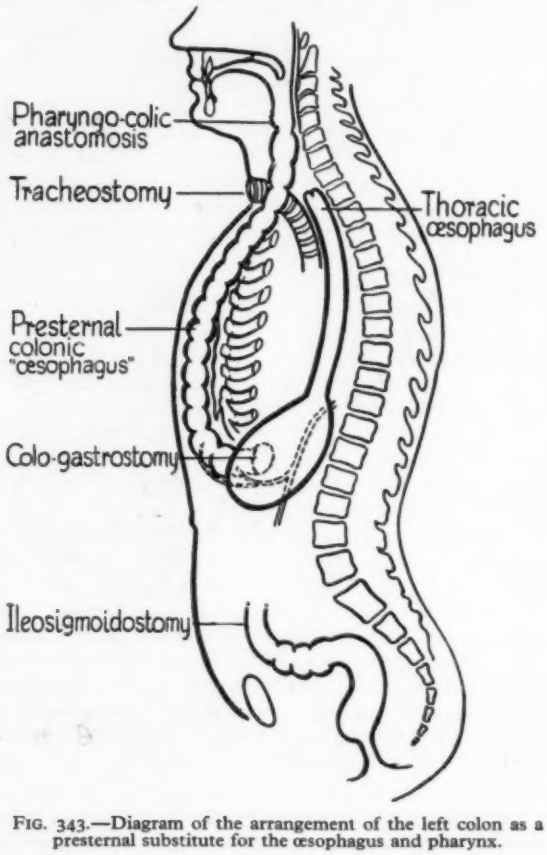



FIG. 343.—Diagram of the arrangement of the left colon as a presternal substitute for the œsophagus and pharynx.

apparently from the posterior pharyngeal wall and spreading anteriorly. Biopsy showed a well keratinized squamous-celled carcinoma.

TREATMENT.—In consultation with Dr. M. Hulbert it was at first decided to treat him by radiotherapy, which was commenced on March 13, 1953. By March 17, however, his œsophageal obstruction had become practically complete and an emergency gastrostomy had to be performed by Mr. A. E. Carter. With gastrostomy feeding his general condition then improved rapidly and it was felt that he would be fit after all to stand radical surgical treatment. Accordingly after a total dosage of 2000 r X-ray treatment was terminated and preparations were made for pharyngolaryngectomy, it being planned to employ the left colon for immediate reconstruction of the pharynx using a two-stage technique for its mobilization as previously described.

*March* 31, 1953: *Stage I, Ligation of Main Vessels to the Left Colon.*—With the patient in a supine position on the table and tilted 25° to the right side a long left paramedian incision was made extending from the pubis to high in the epigastric region. As a consequence of the lateral tilt the loops of small gut gravitated into the right half of the abdomen and exposure of the main vessels supplying the left colon was thereby greatly facilitated. These could easily be seen through the posterior parietal peritoneum without having to mobilize the left colon at all; they had the disposition shown in *Fig.* 342 A. Through a tiny incision in the peritoneum overlying each of the main trunks the two branches of the accessory left colic, the left colic itself, and the first sigmoid artery were doubly ligated with the accompanying veins and divided as in *Fig.* 342 A. The abdomen was then closed in layers.

Recovery from this operation was entirely uneventful. It was intended to proceed to the second stage in approximately two weeks, but as the patient's wife was pregnant and almost at full term it was felt to be only humane to postpone the final hazardous operation till after the confinement, though this would involve a delay of a week or ten days. The labour was actually two weeks late so that some five weeks had elapsed before the second stage was eventually performed.

*May* 8, 1953: *Stage II, Pharyngolaryngectomy and Block Dissection of Cervical Glands with Replacement of Œsophagus by Antethoracic Loop of Left Colon.*—Through a Gluck's incision one of us (I.G.R.) performed the pharyngolaryngectomy and bilateral block dissection, no obvious glands being noted in the cervical tissues removed. Meanwhile the other (J.C.G.) reopened the abdomen through the old left paramedian wound and completed the mobilization of the left colon. The parietal peritoneum on the other side of the descending and upper sigmoid colon was incised, and the greater omentum tied and divided along the length of the transverse colon. The splenic flexure and descending colon could now be swept downwards and medially on a leaf of transverse mesocolon and posterior parietal peritoneum. The sites of previous ligature of the main vessels to the left colon were connected by an incision in the peritoneum. Finally the marginal vessels between the middle colic and right colic arteries below were tied and divided, and the related transverse and sigmoid colon severed between clamps leaving the state of affairs shown in *Fig.* 342 B, the long stump of transverse descending and upper sigmoid colon being nourished solely by the middle colic artery. It was hoped to bring the right colon at the hepatic flexure into continuity with the lower sigmoid colon by end-to-end anastomosis, but the two parts could not be approximated without considerable tension. It was felt safer therefore to resect the entire right colon and establish an end-to-end ileosigmoidostomy.

Attention was now turned to fashioning the mobilized left colon into an antethoracic œsophagus and pharynx. By blunt dissection with long scissors passed from below and from above a subcutaneous tunnel was created along the front of the sternum extending from the upper end of the left paramedian incision to the left side of the neck. This avoided the median plane in the suprasternal region which was to be occupied eventually by the tracheostomy. The sigmoid end of the colon stump was threaded behind the stomach, through the lesser omentum, and along the presternal tunnel to the left side of the neck. When fully extended it was found to stretch almost to the top of the head. The excess was amputated in the neck, it being noted in the process that the vessels in the mesocolon and colon wall bled freely on section. An end-to-end anastomosis was now performed between the upper pharyngeal remnant and the distal end of the colon, using two rows of sutures, a continuous inner stitch of catgut, and an outer layer of interrupted fine silk. A few additional silk sutures were inserted between the muscle masses on the outer side of the pharynx and the colon. The left sternomastoid muscle was divided to accommodate the colon better as it crossed from the front of the chest to the neck. The cervical wound was finally closed, the cut end of the trachea being sutured to the edges of the skin in the suprasternal notch, and rubber drains being inserted down to the pharyngocolostomy. It only remained to anastomose the other end of the colon loop

to the stomach, and as the anterior gastric wall was largely taken up by the gastrostomy the posterior wall was used for this purpose. The abdomen was then closed. The final state of affairs is illustrated in *Fig.* 343.

POST-OPERATIVE COURSE.—During the operation 3½ pt. of blood were given, and the patient's general condition at its conclusion was excellent, P. 110, B.P. 130/80. It had been hoped to make early use of the gastrostomy for feeding, but the development of paralytic ileus necessitated the continuance of fluid and electrolyte administration by the intravenous route for six days. Gastrostomy feeds were then resumed. On the ninth day oral fluids were started and by the twelfth day he was taking semisolids. Thereafter his diet was gradually increased so that three weeks after the operation he was eating ordinary meals. He had no real difficulty in swallowing these, but occasionally found it necessary to massage the food from the lower part of the colonic œsophagus into the stomach. The cervical and abdominal wounds healed *per primam*, the drains being removed from the former on the ninth post-operative day and the stitches from both on the tenth day. Pharyngoscopy on the twelfth day showed the pharyngocolic anastomosis had healed satisfactorily. In spite of the ileosigmoid anastomosis the patient did not have severe diarrhœa when bowel function recommenced after operation, but only two or three motions per day at the most.

As soon as he was well enough to co-operate he was started on speech therapy by Mrs. P. M. Marland, but owing to the small amount of pharynx remaining and the lack of a sphincter to fix the lower limit of the vibrating column of air for voice, progress was naturally slow. On discharge from hospital on June 18 his voice was still a barely audible or understandable buccal pseudo-whisper, with only occasional voicing of words. The state of his general health at this stage can be gauged from the photograph of him shown in *Fig.* 344, and from the fact that he had put on 1½ st. in weight since the operation.

POST-OPERATIVE RADIOLOGICAL EXAMINATION.—On June 6 Dr. T. R. Riley examined the upper alimentary tract after the swallowing of a barium meal and reported: "The liquid barium is easily swallowed by the patient. The anastomosis of the colon to the back of the tongue is working very satisfactorily (*see Fig.* 346 A). The barium is held up for a short time at the site of the anastomosis between the colon and the stomach and there is slight dilatation in the distal part of the colonic œsophagus. This hold-up of barium is overcome by downward massage of the colon segment, which runs down anteriorly to the stomach and then turns back to the anastomosis posteriorly (*Fig.* 346 B). No reflux could be obtained through the œsophageal hiatus into the œsophageal remnant."

PATHOLOGICAL EXAMINATION OF OPERATIVE SPECIMEN (*Fig.* 345) (Dr. R. R. Wilson).—"The specimen consists of the larynx, 2·5 cm. of trachea, the hypopharynx, and the upper 4 cm. of œsophagus. On the anterior wall of the œsophagus there is a deep ovoid undermining ulcer 3·0 cm. long, 1·0 cm. transversely, and 1·5 cm. deep, the upper end of which involves the lowermost part of the larynx without however opening into it or infiltrating the laryngeal mucosa.

"Microscopical examination shows that the floor of the ulcer is composed of granulation tissue, mingled with which are small groups of proliferating carcinoma cells, not very well differentiated. The trachea and the lower edge of the œsophagus appear to be free of growth."

FURTHER PROGRESS.—The patient attended hospital regularly for speech therapy and periodic review. The improvement in his general health and speech continued, but when examined on July 21, 1953, it was found that he had developed a hard slightly tender nodular swelling in the upper part of the left side of the neck. There can be little doubt that this is due to a recurrence of his growth. He is now having a course of radiotherapy under the care of Dr. M. Hulbert, but it is scarcely to be hoped that this will do more than delay the fatal outcome.

## DISCUSSION

**1. Severity of Operation.**—There can be no denying that pharyngectomy with replacement of the œsophagus and pharynx by colon, involving as it does a major abdominal operation with two intraperitoneal anastomoses in addition to a pharyngolaryngectomy and block dissection of the neck, is a procedure of considerable magnitude. The abdominal dissection, however, can be carried out with negligible blood-loss, and, if two operators are available, as they were in our case, it can be synchronized with the neck dissection so that the total operating time is much reduced. We attach the greatest importance to the choice of the presternal route for the upward transmission of the freed colon. This avoids the shock and disturbance of a thoracotomy and excision of the thoracic œsophagus, and probably contributed largely to the immediate success of the operation in our case. We found that the creation of a subcutaneous tunnel for the colon was a very simple step requiring only a little blunt dissection from below and above with a long pair of scissors.

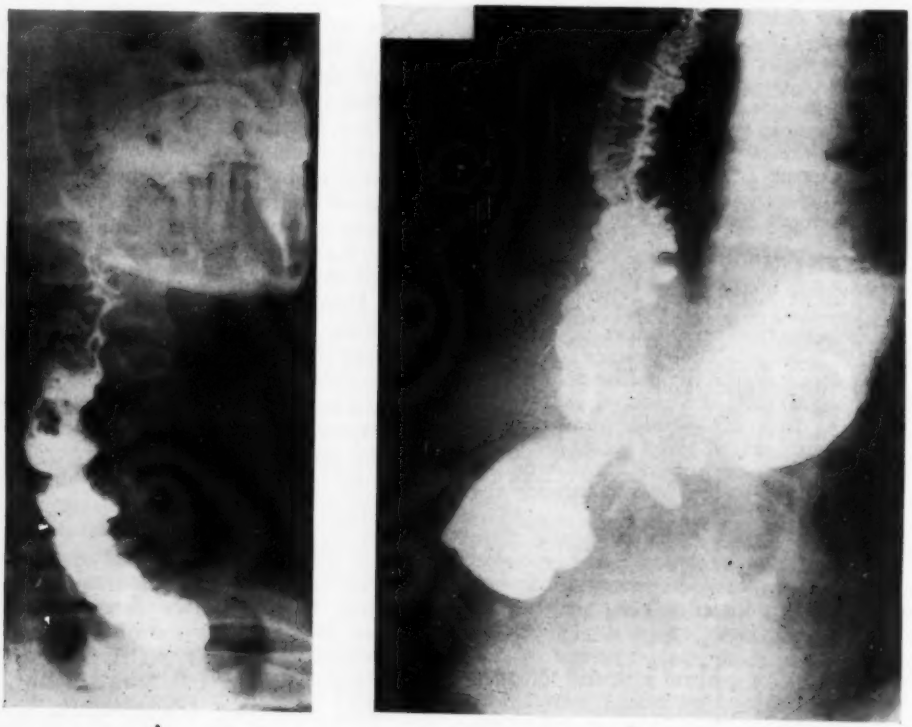
**2. Healing of the Pharyngocolic Anastomosis.**—Our experiences with anastomoses between the sigmoid colon and rectum after resection of rectal carcinomata have shown that, even with an apparently adequate blood-supply to the colon and rectal stumps as indicated by free bleeding from their cut ends at the time of operation, subsequent partial breakdown of the suture line and leakage of fæces occasionally occurs without frank necrosis of bowel (Goligher, 1951). Fortunately, these defects almost invariably heal up satisfactorily in two or three weeks without ill effect. We should not, therefore, have been surprised if there had been a temporary failure of union of some part of the pharyngocolonic suture line in this case, but we hoped that with the free passage of saliva down the colonic œsophagus the resulting salivary fistula would soon close. In the event, however, the anastomosis healed entirely without incident.

**3. Healing of the Closed Stump of the Thoracic Œsophagus.**—Trouble might also have been apprehended from leakage from the blind end of the thoracic œsophagus closed in the root of the neck. However carefully an œsophageal stump may be sutured, from the nature of its wall it is unlikely that the same security of closure or rapidity of healing could be achieved as with a blind end of stomach or intestine. A significant factor in the uneventful healing of the œsophageal stump in this case probably was the absence of regurgitation of gastric contents into the œsophagus, for at no stage of the post-operative barium series examination, even on inversion of the patient, could the meal be made to enter the œsophagus from the stomach.

**4. Physiology of Swallowing with Antethoracic Colonic Œsophagus.**—As the colonic segment between the mouth and the stomach is placed in an antiperistaltic direction, clearly only hindrance to the act of deglutition could result from

FIG. 344.—Post-operative photograph of the patient after substitution of colon for pharynx and œsophagus. Note the incisions used and the prominence caused by the antethoracic position of the colonic 'œsophagus'.

FIG. 345.—Photograph of the operative specimen, showing elongated deep malignant ulcer on the anterior wall of the cervical œsophagus extending proximally as far as the hypopharynx. This growth invaded the laryngeal wall but did not reach to its mucosa. Histologically it was found to be a poorly differentiated squamous-celled carcinoma.



A B

FIG. 346.—Barium swallow examination after colonic pharyngo-œsophagoplasty: (A) Lateral view of the colon in the neck showing the pharyngocolic anastomosis just below the back of the tongue; (B) Oblique view of the lower end of the colon segment where it joins the posterior aspect of the stomach.

colon peristalsis. It is doubtful, however, whether an isoperistaltic arrangement of the colon, if that had been possible, would have helped, because the *tempo* of peristalsis in the colon would probably be too slow to affect the downward passage of food. As it was, deglutition was initiated by the muscles of the tongue and the small pharyngeal remnant which projected the food backwards and downwards into the colon, its subsequent passage depending entirely on the influence of gravity. We feared that the small amount of pharynx remaining might be insufficient for this initial active movement and that solid food might stick in the upper part of the colonic œsophagus, but, as stated, our fears were unfounded. As a rule swallowing occurred quite easily in our patient provided he was in a sitting or reclining position, but sometimes with solids he did find it necessary to massage the food downwards from the lower part of the colon into the stomach by a rubbing movement of the hand on the front of the chest. Surprisingly enough, the taking of solid food did not necessitate drinking large quantities of fluid throughout the meal to wash the bolus down. He could eat a three-course lunch like any ordinary individual in about twelve to fifteen minutes.

**5. Speech Training.**—This was started as soon as healing of the anastomoses was complete, the aim being to develop a 'pharyngeal' voice using the displaced colon as a reservoir. Articulation was effected by movements of the back of the tongue. Although the volume of voice is as yet poor, the intelligibility of speech in this patient is already remarkable. The technique of speech therapy is that worked out by Marland (1949 and 1951) on the basis of the personal experiences of Sawkins (1949), who had had a laryngectomy.

**6. Risk of Peptic Digestion of Lower End of Colonic Œsophagus.**—Our experience of colonic replacement of the stomach after high partial gastrectomy for duodenal ulcer (unpublished data), and that of Moroney (1953) of the same manœuvre, has shown that colon exposed to the action of gastric juice is liable to undergo peptic digestion. In this patient with a colonic œsophagus some regurgitation of gastric contents is presumably apt to occur through the colo-gastric anastomosis with a similar risk of peptic ulceration developing in the colon. Yudin (1944) has drawn attention to the complication of peptic ulcer arising in the jejunum after jejunal œsophagoplasty for œsophageal strictures, if the lower end of the jejunal œsophagus is implanted into the stomach. To avoid this danger he recommended anastomosing the jejunal "œsophagus" below to a loop of small bowel. Sweet (1950) however has commented on the difficulty of maintaining satisfactory nutrition of the patient if this technique is employed, and it was because of this criticism that we carried out colo-gastrostomy in our patient. In so doing we had in mind the reflection that this patient might only survive for a year or so at most and that this arrangement might serve him well in that time. It is difficult to foresee what symptoms might be produced by a peptic ulcer in the colonic œsophagus apart from those referable to hæmorrhage or perforation, but if pain of ulcer type were to occur as it did in our gastrectomy cases with recurrent ulceration after colonic replacement, it might be possible to diagnose the condition and to re-operate, transferring the anastomosis from the stomach to the jejunum.

**7. Alternative Technique for Use of Colon in Reconstruction of Pharynx.**—Though the technique employed in this case has worked well, a nearer approach to the ideal would be to use only the terminal part of the mobilized colon to bridge the actual gap between the upper pharynx and the stump of the thoracic œsophagus. Owing to the fact that an interval of $\frac{3}{4}$ in. to 1 in. separates the marginal artery from the colon, it is quite easy in thin subjects, in whom the vessels stand out clearly, to ligature and divide the numerous cross branches that run from the marginal artery to the bowel without damage to the former. In this way the transverse and descending colon can be separated from their marginal vessel in the long left colon stump for a considerable distance, till only a short segment of lower descending and upper sigmoid colon remains still attached to its marginal artery, as in *Fig.* 347. In two patients undergoing complete colectomy for polyposis coli we have manufactured such colonic pedicle grafts and have been satisfied from the free bleeding at their cut edges that they probably had an adequate blood-supply for survival. In the case described in this paper we were actually hoping to employ this technique to prepare in two stages a short segment of colon to be taken up to the neck with a long vascular pedicle through a presternal subcutaneous tunnel for implantation by end-to-end suture into the defect created by the pharyngectomy. However, there was too much fat in the patient's mesocolon for the manœuvre of separating the proximal part of the colon stump from the marginal artery to be carried out without endangering the integrity of the latter, and so the less ambitious plan

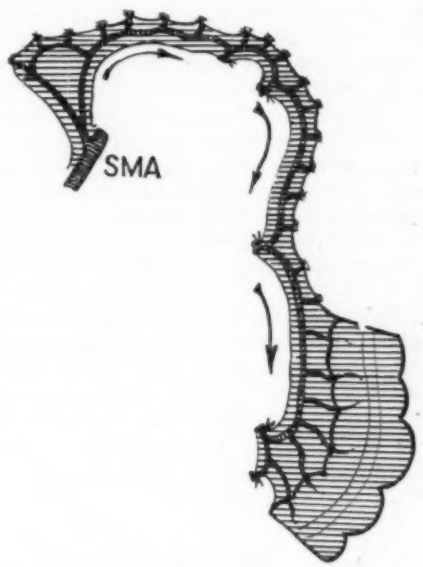



FIG. 347.—Diagram indicating how, by ligation and division of the branches proceeding from the marginal artery to the proximal two-thirds or more of the left colon stump shown in *Fig.* 342, B, a short segment of lower descending and upper sigmoid colon nourished by a long vascular pedicle may be prepared.

of an antethoracic œsophagoplasty was adopted instead But we think that in a suitably thin subject such a pedicle graft of colon could be prepared for segmental replacement after pharyngectomy or high œsophageal resection.

## SUMMARY

1. The possibility of elevating to the neck for anastomosis to the upper pharyngeal remnant after pharyngectomy of a tube of œsophagus, stomach, jejunum, and colon respectively is examined, and the conclusion reached that suitably mobilized left colon offers better prospects than any other viscus for the success of this manœuvre. A two-stage technique is advocated for the freeing of the colon.

2. A case is described in which an antethoracic œsophagopharyngoplasty using left colon was successfully employed to restore continuity with the stomach after pharyngectomy for carcinoma of the pharynx. Some of the technical problems and physiological consequences of this procedure are discussed.

We wish to thank Dr. V. Wynn for his valuable assistance in the maintenance of post-operative fluid and electrolyte balance in this case; Miss P. M. Marland, L.C.S.T., for her comments on speech therapy; Dr. T. R. Riley for the pre- and post-operative radiological examinations; Dr. R. R. Wilson for the pathological report; and Dr. P. N. Cardew for the photographs.

## BIBLIOGRAPHY

BIRCHER, referred to by YUDIN, S. (1944), *Surg. Gynec. Obstet.*, **78**, 561.
GARLOCK, J. H. (1948), *Surgery*, **24**, 1.
GOLIGHER, J. C. (1951), *Postgrad med. J.*, **27**, 568.
— — (1954), *Brit. J. Surg.*, **41**, 351.
VON HACKER (1914), *Arch. klin. Chir.*, **105**, 973.
HARRISON, A. (1949), *J. thorac. Surg.*, **18**, 316.
KELLING, referred to by YUDIN, S. (1944), *Surg. Gynec. Obstet.*, **78**, 561.
LEWIS, EMLYN (1952), *Proc. R. Soc. Med.*, **45**, 258.
MACMANUS, J. E., DAMERON, J. T., and PAYNE, J. R. (1950), *Surgery*, **28**, 11.
MARLAND, P. M. (1949), *Speech*, **13**, 4.
— — (1951), "Laryngectomy Teaching Records for Gramophone" Brit. Homophone Co. Ltd.
MORONEY, J. (1953), *Ann. R. Coll. Surg. Engl.*, **12**, **328**.
ORSONI, P., and TOUPET, A. (1950), *Pr. méd.*, **58**, 804.
— — (1951), *Ibid.*, **59**, 272.
— — and LEMAIRE, M. (1951), *J. Chir., Paris*, **67**, 491.
OWEN, R. D. (1950), *Proc. R. Soc. Med.*, **43**, 157.
PARKER, E. F., and BROCKINGTON, W. S. (1949), *Ann. Surg.*, **129**, 1588.
ROB, C. G., and BATEMAN, G. H. (1949), *Brit. J. Surg.*, **37**, 302.
ROBERTSON, R., and SARJEANT, T. R. (1950), *J. thorac. Surg.*, **20**, 689.
ROUX, C. (1907), *Sem. méd., Paris*, **27**, 37.
RUDLER, J. C. (1951), *Rev. Chir.*, **70**, 193.
SAWKINS, J. (1949), *Med. Pr.*, **222**, 193.
SWEET, R. H. (1946), *Ann. Surg.*, **124**, 653.
— — (1948), *Surgery*, **23**, 952.
— — (1950), in discussion of paper by Robertson, R. and Sarjeant, T. R.
SWENSON, O., and CLATWORTHY, H. W. (1949), *Surgery*, **25**, 839.
TROTTER, W. (1913), *Lancet*, **1**, 1075.
VULLIET, H. (1911), *Sem. méd., Paris*, **31**, 529.
WOOKEY, H. (1940), *Brit. J. Surg.*, **27**, 696.
WOOLER, G. (1952), *Proc. R. Soc. Med.*, **45**, 264.
YUDIN, S. (1944), *Surg. Gynec. Obstet.*, **78**, 561.

# THE USE OF AN ISOLATED LENGTH OF ILEUM AS A URINARY CHANNEL

BY DAVID ANNIS, W. R. HUNTER, AND CHARLES WELLS
DEPARTMENT OF SURGERY, UNIVERSITY OF LIVERPOOL

URETEROCOLIC anastomosis is an unsafe and uncertain operation that carries with it many early and more late complications.

We became gradually aware of the unsatisfactory results of ureterocolic anastomosis during the late 1940's and, with many others, we sought a method that might not bring with it the toll of complications we had come to expect after the usual Coffey I operation. Direct mucosa-to-mucosa elliptical anastomosis between ureter and colon seemed at first to offer some improvement, but by 1951 it was obvious to us (Wells, 1951) that the late complications of this operation were formidable and we abandoned its use. That the mucosa-to-mucosa method of Nesbit was the latest of sixty or more methods that have been described suggests to us that technique alone cannot notably affect the fundamental unsoundness of implanting the ureters into the intact bowel.

The dilemma inherent in the technique of ureterocolic anastomosis is that the greater the effort to produce a valved union the greater is the chance of producing stenosis at the anastomosis, with dilatation and destruction of renal substance. Again, the wider and the more freely draining the anastomosis the greater is the chance of reflux of intestinal contents into the ureter with repeated attacks of renal infection and destruction. Either way the incidence of severe renal damage is high.

It is not always possible by the most careful technique to achieve a free flow from a valved ureterocolic anastomosis. Unpredictable occurrences such as a hæmatoma, œdema, or kinking at the site of union, infection, sloughing of the tip of the ureter, or a slight excess of tension on a single suture, all may play their part in producing a poor result.

Grey Turner wrote: "effects (of ureterocolic anastomosis) on the kidney and ureter are very striking. In the first few weeks the pelves may be dilated and this dilatation may persist or increase." Dean (1950) found that hydronephrosis developed rapidly in many of his 99 cases, and he says that 11·6 per cent of those who survived the operation

required a further operation, within three months of the transplantation, for its correction. Henderson (1952) found a similarly high incidence of stenosis at the anastomosis and described a number of operative procedures for its relief. Pool and Cook (1950) made a urographic study of 45 patients who had bilateral ureterosigmoidostomies. Only 5 had perfectly normal pyelographic appearances; the rest had pelvic deformities of varying degree. Hydronephrosis was the commonest.

Renal damage, whether due to progressive hydronephrosis or to repeated attacks of pyelonephritis, brings with it the later complications of renal stone and of pyonephrosis. Biochemical disturbances also occur, of which uræmia, hyperchloræmic acidosis, and hypokalæmia are common. The work of Lapides (1951), Parsons, Powell, and Pyrah (1952), and our own work (Annis and Alexander, 1952) suggests that these late biochemical complications are unlikely to become clinically discernible in the presence of good renal function. The preservation of renal function is, therefore, of prime importance.

It seemed to us that ureterocolic anastomosis in any of the many forms that had then been devised could not be relied upon to preserve good renal function and that the results were uncertain and capricious. We therefore sought not a better ureterocolic anastomosis, but a better alternative to ureterocolic anastomosis.

Folsom (Folsom and O'Brien, 1941) has summarized the essentials of an ideal method of diversion of urine from the kidneys; he says it should "... insure continued normal kidney function without disposing to damage by infection or obstruction and would enable the patient to live a normal life without constant need of medical care. In addition the method of diversion should be relatively free from danger in its application without a high mortality or a period of long confinement."

If the ureters are not to be implanted into the intact colon then two possibilities remain—either urine may in some way be brought to the skin surface to be collected in an appliance or, alternatively, some internal receptacle may be fashioned. Many ingenious efforts have been made to achieve the latter purpose, Remedi (1906), Krönig (1907), Hinman and Wayrauch (1936), Glaser (1952), and Pyrah (1954) used the isolated rectum into which the ureters were implanted. Good results seem to have been secured by this method but, in return for freedom from renal infection, the patient has to bear the burden of a colostomy.

To overcome this disadvantage attention has been turned by Verhoogen and de Graeva (1909), Makkas (1910), Merricks, Gilchrist, Hamlin, and Rieger (1951), Glaser (1952), Bricker (1950), to the making of an internal reservoir from the isolated cæcum and terminal ileum. Here the intestinal continuity is restored. The patient empties the isolated cæcal pouch by catheterization. Bricker abandoned this method in favour of external collection of urine. He used an isolated channel of ileum to direct the urine from both renal pelves. His patients had complete removal of the pelvic viscera and the operation was devised as an alternative to a wet colostomy.

Bricker's method of urinary diversion is one which we have used, but most of our cases have been done with total cystectomy for carcinoma of the bladder. The use of ileum simply makes for a more convenient form of cutaneous ureterostomy.

Cutaneous ureterostomy has been used often during the last sixty years, but it was displaced when ureterocolic anastomosis became more widely used. However, Cabot and Scherer (1935), at the Mayo Clinic, said that they preferred to bring a dilated ureter to the surface rather than anastomose it to the colon and, throughout, this has been the practice of a minority of surgeons. As recently as 1950 Trabucco and Marquez wrote that if there is evidence of renal failure or if the ureters are dilated they prefer to perform cutaneous ureterostomy rather than ureterocolostomy.

Keyes (1940) wrote of cutaneous ureterostomy in the treatment of intractable tuberculosis of the bladder. He reviewed the progress of 6 patients for whom, at some time, one kidney had been removed and tuberculous disease of the bladder had persisted. His patients had survived the operation for periods of from three to thirteen years. They were well and were able to keep dry; one had married and another had borne a child. In three there was tuberculosis in the kidney whose ureter had been brought to the surface. These three patients needed an indwelling ureteral catheter and two of them developed phosphatic stones.

Keys felt that renal infection was unlikely unless an indwelling collecting apparatus was needed.

Despite these and other enthusiastic reports (Mathé, 1944; Folsom and O'Brien, 1941; Keyes, 1943) the operation of direct cutaneous ureterostomy has never been popular with most surgeons for two main reasons. Firstly, the patient must wear a collecting apparatus that is often bulky, uncomfortable, and not always completely effective, and, worse, if the operation is performed for bladder disease the patient may have to contend with two ureterostomies. Certainly, from the point of view of convenience alone they are more handicapped than the patient who has a ureterocolic anastomosis. Secondly, because the ureter has a precarious blood-supply it is impossible to be certain that the viability of the divided end is not jeopardized when it is brought to the surface. A common experience with simple ureterostomy is that the ureter sloughs and disappears deep into a skin cleft; stenosis gradually develops at the ureterocutaneous junction and an indwelling catheter is needed for satisfactory collection. This often results in ascending infection little better than that following ureterocolic anastomosis.

To exploit the advantages of ureterocutaneous anastomosis and yet to overcome some of its drawbacks we turned to ileocutaneous ureterostomy. In the circumstances in which we would formerly have done ureterocolic anastomosis, we transplanted the ureters into an isolated length of ileum, the upper end of which was closed and the lower end brought out as a urine-draining ileostomy. Onto this was affixed one of the bags worn by patients having an ileostomy for ulcerative colitis. No indwelling apparatus is required, and stenosis at the ileocutaneous junction need never occur. Drainage of urine to the exterior is usually unimpeded and rapid. This operation has been performed by us for 31 patients,

and an account of their progress will form the main substance of this paper.

Looking back over the last fifty years we find that the feasibility of using an isolated length of small intestine to act as a conduit for urine has been amply demonstrated by the experimental work of Poggi and Tizzoni, Matsumoto (1938), Mersheimer, Kolarsick, and Kammandel (1950 : 1951), MacLean and Fais (1952), and our own work (Annis, 1952). Concurrently, occasional reports have been made of its successful use in human surgery to replace a diseased or damaged ureter or to make an artificial bladder when, for one reason or another the natural bladder ceases to be an adequate reservoir. (Berg, 1907 ; Nissen, 1940 ; Longuet, 1948 ; Ulitzch, 1949 ; Müller, 1950.)

An isolated loop of small intestine has been used to increase the capacity of a contracted bladder (Scheele, 1923 ; Couvelaire, 1951 ; Pyrah, 1954 ; and ourselves) and good results have been claimed for these operations. In our own experience we were impressed with the normal appearance of our dogs that remained healthy for the duration of our experiments (twelve months) having a solitary kidney attached to the bladder by a length of ileum (Annis, 1952). McLean and Fais (1952) reported a more detailed study and recorded a similar experience. On this evidence and the favourable clinical reports we felt able to apply this knowledge to the practice of human surgery.

We have used the isolated ileal loop as an alternative to ureterocolic anastomosis in the following circumstances :—

1. During the operation of total cystectomy for carcinoma of the bladder (21 cases). (In addition, an ileocutaneous anastomosis has been done for 2 patients in whom it was not possible to proceed to total cystectomy.)

2. To divert urine from a kidney where intramural fibrosis of the bladder has caused ureteric stenosis and where the other kidney has been removed for tuberculosis (1 case).

3. For malignant vesicovaginal fistula (4 cases), and in an additional case for carcinomatous involvement of the ureters.

4. To divert urine during operations for extensive pelvic carcinoma involving both bladder and rectum as an alternative to a wet colostomy (1 case).

5. To divert urine in a patient incontinent and with a perineal fistula due to a long fibrous stricture of the urethra (1 case).

6. To replace a length of diseased or damaged ureter and to re-establish the ureteric continuity where this cannot be achieved by simpler methods of repair (3 cases).

7. To increase the capacity of a contracted bladder by the use of an ileal ' diverticulum ' (1 case).

## 1. TOTAL CYSTECTOMY WITH ILEOCUTANEOUS URETEROSTOMY

This operation has undergone minor modifications since we described it in 1953 (Annis, Hunter, and Wells, 1953).

Total cystectomy has been carried out by the method of Millin and Masina (1949). The operation has been completed with an ileocutaneous transplantation of the ureters as a single-stage operation in all 21 cases. In this operation the ureters are divided a little below the pelvic brim and the left ureter brought through the pelvic mesocolon to lie on its medial side. An 8–12 in. length of ileum is selected, usually within a foot of the ileocæcal valve, but the exact site for division of the bowel and of its mesentery depends upon the anatomical arrangement of its blood-supply. The mesentery is divided to points about 2 in. from the bowel, leaving as wide a mesenteric pedicle as is possible. The continuity of the small bowel is restored above the isolated loop. Our main anxiety after operation has been on account of abdominal distension with ileus or obstruction or a little of both ; it is difficult to be sure which, and we have employed both end-to-end and side-by-side anastomosis. We can only say that whichever is selected, interrupted sutures should be used and special care taken to avoid constriction of the lumen. This may be achieved by sewing the mucosal and sero-muscular layers separately, avoiding inversion.

The segment of ileum is attached along the pelvic brim, lying from left to right, and the ureters implanted at convenient points along it. The exact method of anastomosis between ureters and the isolated loop has varied. One of us (W. R. H.) has closed the proximal end of the loop and has implanted the ureters by a method similar to that described by Stiles for ureterocolic anastomosis.

Some patients have had a formal mucosa-to-mucosa anastomosis, the left ureter being divided obliquely and joined to the open proximal end of intestine. The right ureter has been similarly divided and anastomosed to an elliptical opening made into the side of the loop. Because of the occasional slight leakage from this form of anastomosis, in some more recent cases we have tied catheters into the ureters, brought the catheter through small stab incisions in the ileal loop, and led them out of the ileostomy to drain at the surface. These tubes have fallen out during the ensuing few days. The choice of techniques is discussed later.

In all instances the loop has been lightly tacked to the peritoneum along the pelvic brim, and the distal end of the ileal loop has been brought out through the stab incision in the right lower abdomen at a point about half-way between the umbilicus and the anterior superior iliac spine. Because the loop lies along the pelvic brim the ileostomy may be made a little lower than the usual site in the patient with ulcerative colitis. Some of the patients have had a skin-covered ileostomy spout fashioned in the manner described by Wells (1952) ; in others the ileal loop has been allowed to protrude ¾ in. beyond the skin surface, to shrink back, and form a small mucosal ' button '. Around this the flange of an adhesive bag is applied. Whichever method is used, to avoid later difficulty in fixing this bag, it is important to keep the ileostomy away from the groin crease, the iliac crest, the umbilicus, or from any skin incisions.

**The Selection of Cases for Operation.**—The choice of cases to be submitted to total cystectomy is a difficult one ; indeed, some may doubt whether total cystectomy has any place in the treatment of bladder tumours. Our indications for total cystectomy have remained unchanged, and only the method of dealing with the divided ureters has altered. It may be, however, that total cystectomy will find a

wider field of usage, for hitherto many of the complications of total cystectomy with ureterocolic transplantation have been the consequence of the anastomosis and not of the primary disease. If the operation of ileocutaneous ureterostomy can substantially reduce the morbidity and mortality of ureteric transplantation, we should then have a clearer picture of carcinoma of the bladder and its treatment by total cystectomy *per se*. We may then feel more confident in recommending it.

In this series all the 21 patients for whom total cystectomy and ileocutaneous transplantation of the ureter has been done had histologically proven carcinoma of the bladder. They fell roughly into two groups—those with ulcerating or nodular infiltrating growths, discovered as such and usually palpable on bimanual examination, and those with papilliferous lesions, frequently diffuse within the bladder. This latter group came from a bigger group of such patients and they were the patients for whom we were forced to this radical form of treatment, either because of extensive disease within the bladder or, more usually, because simpler measures, such as repeated fulguration, suprapubic diathermy excision, radon seed implantation, and partial cystectomy had failed to control the growth.

**Post-operative Complications.**—No-one will deny that total cystectomy in itself is a formidable and often difficult operation, and to this must be added the risks of an ileal resection and anastomosis and of ureteric transplantations. However, when the dangers and complications are assessed and judged one must be mindful of the inevitably fatal nature of the disease itself and of the many dangers and serious complications of total cystectomy with the usual ureterocolic transplantation.

Many of our patients had some degree of post-operative ileus and this contributed, with other complications, towards the death of 3 patients. Apart from these three patients 2 have required a further operation; in 1 an ileostomy had to be made that drained for two or three days and then closed spontaneously. In a second an obstruction of the pelvic colon resulted probably from an attempt to repair the pelvic peritoneal floor following cystectomy and hysterectomy; this required temporary intestinal drainage. The other patients who developed some degree of ileus responded to post-operative gastric suction and to intravenous fluids.

Leakage of urine from the site of anastomosis between the ureter and ileum occurred in 4 patients; one of these patients, mentioned above, developed paralytic ileus and died; the other three patients required no surgical treatment and the fistulæ closed, each within a few days.

One other patient did not pass urine following the operation, and in consequence a ureter was explored and drained. When blood-clot was removed from the ureter a free flow of urine resulted. Wound dehiscence occurred in 4 patients and required re-suture. In 2 of these patients the wound repeatedly failed to heal and these patients died. Both were extremely poor operative risks. The other patients, one a man of 80, made satisfactory recoveries.

Many of these early post-operative complications, serious as they have been, do not seem to have occurred with a frequency greater than has been found immediately following total cystectomy with ureterocolic transplantation. A study of Jacobs and Stirling's paper (1952), which summarizes a collected series of 1670 cases, clearly shows this.

It may be added that amongst our patients one was over 80 years of age, three were in their seventies, and six were in their sixties.

**Causes of Death.**—It will be seen that in the 4 patients who died there was a multiplicity of complications responsible for the fatal outcome.

One patient, a woman aged 73, otherwise perfectly well and in whom there was a free and adequate urinary flow from the ileocutaneous ureterostomy, was up walking around the ward when she died suddenly. Post-mortem showed the cause of death to be massive pulmonary embolism.

One patient, a man aged 59, died as the result of a prolonged period of ileus from which he never recovered. The condition was complicated by the presence of a urinary fistula from one ureteroileal anastomosis. He died 2½ weeks after the operation.

The third patient, a man aged 64, died some five weeks after the operation following repeated attempts at closure of a wound dehiscence. All signs of wound healing were absent and a week before he died the ileal loop prolapsed through the wound.

The fourth patient, a man aged 46, was admitted with severe hæmaturia and clot retention, for which repeated blood transfusions were necessary. After total cystectomy and ileal transplantation of the ureters he developed some degree of small-intestinal obstruction, and the abdominal incision gave way ten days later. Eight days after secondary closure the wound burst again. At post-mortem the ileocutaneous ureterostomy was intact and the kidneys were normal.

**Progress of the Patients.**—More than two years have passed since the first of these operations was done and all the patients have been seen at six-monthly intervals. So far no patient who survived the operation has died from the recurrence of carcinoma, and in only 1 case is there clinical evidence of metastatic spread. One patient died suddenly of coronary thrombosis two months after his operation; until that time he had remained satisfactory from the point of view of his cystectomy and ileal transplantation. Another patient, aged 73, died of pneumonia nineteen months after her operation. The urine-draining ileostomy worked well until she died.

No patient has had a single attack of back pain, chills, or fever, suggestive of pyelitis, since discharge from hospital, though one patient, Mr. H., had such signs and symptoms during the first three weeks after an infected non-functioning kidney was transplanted; these symptoms have not returned during the subsequent sixteen months, and, radiologically, function has returned to this kidney.

All the other patients have remained generally well and most have regained their pre-operative weights. None has shown undisputed clinical evidence of acidosis.

**Collection of Urine.**—With one exception all the patients remain dry and comfortable and have learned to look after the collecting bag. The exception is a patient who was done early in the

series and he has some difficulty in keeping dry at night. In this case the ileostomy was brought out through the operation wound. Subsequently he gained 2 st. in weight and the ileostomy shrank deep into a furrow, making it difficult to fit the collecting apparatus satisfactorily; the same error has not been repeated.

No patient has expressed himself dissatisfied with the method of collection and some have acquired a

FIG. 348.—Showing the collecting apparatus.

quite remarkable confidence and skill. One patient, Mr. S., devised the collecting apparatus now in general use and he says he only needs to change the adhesive flange every Sunday afternoon and puts on a new detachable bag each day. He feels fit and has gained 3 st. in weight since his operation. In this respect he makes the pertinent observation that the adhesive bag sticks better to a nicely rotund abdomen! This bag, which is also being used with success in ulcerative colitis, is made for us by Charles Bullen of Liverpool. (*Fig.* 348.)

One of us (W. R. H.) expresses a divergent view on the matter of the most satisfactory method of collection, and feels that although the application of an adhesive bag is in many cases satisfactory, it needs careful attention and old people might find this difficult.

Moreover the skin of some people will not tolerate the adhesive material. In such cases a spout ileostomy offers many advantages, its only drawback being that it takes a little longer to fashion. In the cases in which a spout has been made he is impressed with the value of this procedure. A spout must be 1½ to 2 in. long and must curl downwards. To obtain a downward draining spout the upper surface is covered with full-thickness skin and the lower part with the split-skin graft, and, as the latter contracts, it curls downwards, so fitting nicely into the apparatus. When the patient is up he is able to keep dry very easily by wearing an ordinary non-adhesive bag. It is at night that leakage is most likely to occur and then a bag with a lightly fitting perforated diaphragm is used. This type of bag must not be worn throughout the day lest the pressure should cause ulceration of the spout, but it may safely be used during the night. One must ensure that the diaphragm grips the spout only very lightly. In addition the patient must see that the bag does not overfill. The tap at the bottom of the bag can be unscrewed and a fitting attached, which leads over the side of the bed into a bottle. This is used at night.

At the bottom of the bag, a small tap is better than the usual screw stopper, as the latter is difficult to manipulate. The ring of the bag need not fit too snugly around the base of the spout and in fact it is better that it should not do so, as a closely fitting ring often causes œdema.

**Return to Work.**—Most of the patients have been 60 years of age or over and had already retired from work. The younger ones have without exception returned to their work.

**Biochemical Changes.**—Biochemical changes incidental to the operation and the renal changes as

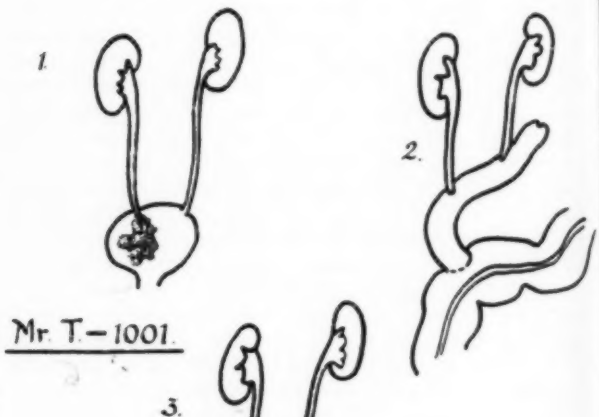



FIG. 349.

judged by intravenous pyelography differ in no way from those in whom ileocutaneous ureterostomy has been done for conditions other than carcinoma of the bladder. They will be discussed together later in this paper.

## CASE REPORTS OF THE 17 PATIENTS SURVIVING TOTAL CYSTECTOMY AND ILEAL TRANSPLANTATION OF THE URETERS

*Case* 1001.—Mr. T., aged 60. Generalized papilliferous carcinoma of the bladder. In January, 1952, total cystectomy was performed with an open mucosa-to-mucosa anastomosis of the ureters to an isolated ileal loop.

The distal end of the ileal loop was implanted into the pelvic colon as a side limb in an effort to prevent regurgitation of intestinal contents. He was discharged home on Jan. 28, 1952, and at that time the blood chemistry and intravenous pyelograms were normal. In May, 1952, he came back because of intermittent fever and pain in the loins. The general state of health was reasonably good, and certainly no worse than after an ordinary

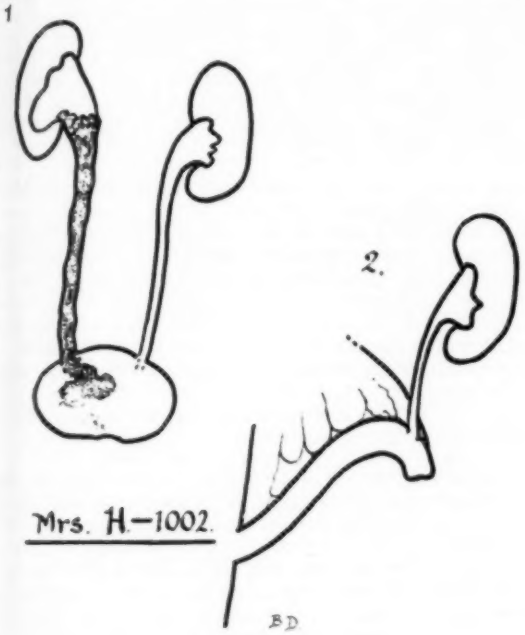



FIG 350.

ureterocolic anastomosis. However, the operation had failed in its main purpose and in June, 1952, the ileal loop was separated from the colon and brought to the skin surface (*Fig.* 349). All clinical signs of renal infection ceased and have not recurred during the last two years. He has gained 2 st. in weight, the intravenous pyelogram shows normal renal appearances, and the blood-urea remains at 48 mg. per cent. Because the ileum was brought out through the main incision there has been some difficulty in fixing the collecting apparatus. Now he remains dry throughout the day, but there is occasional leakage of urine at night. He has returned to his former employment.

*Case* 1002.—Mrs. H., aged 71. This patient had a papilliferous carcinoma involving the right half of the bladder, the right ureter, and renal pelvis. In April, 1952, a right nephro-ureterectomy and cystectomy was performed and the remaining ureter was transplanted into an ileal loop (*Fig.* 350). She made a good recovery and found no difficulty in managing an adhesive ileostomy bag of the Rutzen type. Mr. Daniel, of Lancaster, has kindly kept in touch with her and he reports that she remains well, walks two miles each day, and says she is living an enjoyable and useful life. She says that she is able to keep dry both by day and night. An intravenous pyelogram shows a normal renal outline. The blood-urea eighteen months after her operation is 70 mg. per cent. (We learn that this patient died recently. Death was reported as being due to pneumonia. The ileocutaneous ureterostomy worked normally throughout her last illness.)

*Case* 1003.—Mr. C., aged 44. This man had a profuse papilliferous carcinoma of the bladder. Preoperative intravenous pyelogram showed a large filling defect in the bladder with some hydronephrosis on the right side. The left kidney showed a normal appearance. In October, 1952, a total cystectomy with ileocutaneous ureterostomy was done, the ureters being implanted into the ileal loop by Stiles technique (*Fig.* 351). He was discharged from hospital three weeks later. Collection has been from a skin-covered ileostomy spout into a non-adhesive rubber bag and is entirely satisfactory.

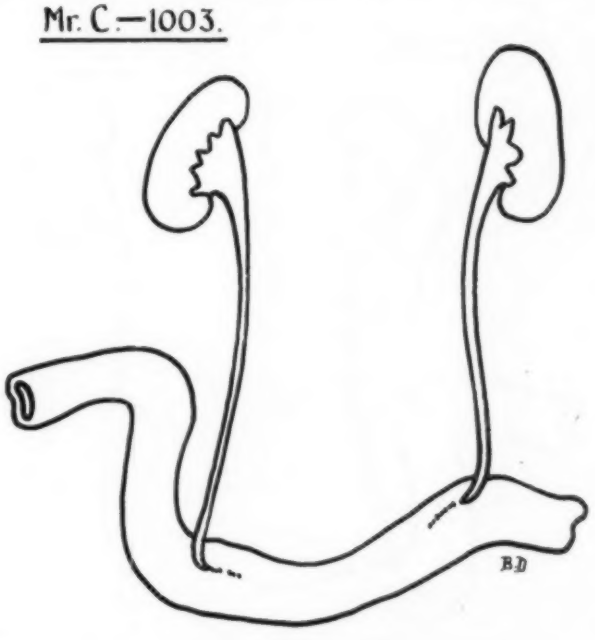



FIG. 351.

Eighteen months later an intravenous pyelogram shows a normal renal outline on the left side and a slight increase of the already hydronephrotic right kidney. The blood-urea is 35 mg. per cent. There has been neither loin pain nor fever.

*Case* 1004.—Mr. H., aged 60. This patient had an infiltrating nodular carcinoma of the bladder. An intravenous pyelogram showed no function of the right kidney and some dilatation of the left. In January, 1953, a total cystectomy with ileal transplantation was performed, the ureters being anastomosed by a direct elliptical union. For the first three weeks after operation there were signs suggestive of pyelitis of the non-functioning kidney but these cleared and have not returned. He wears a non-adhesive ileostomy bag and remains dry throughout the day. There is, however, a little leakage at night. Sixteen months after the operation he remains in excellent health and is at work in a canteen. An intravenous pyelogram shows a return of function on the right side but some recent increase of the left-sided hydronephrosis. This renal distension has coincided with a delay in emptying of the ileal loop. Dilatation of the ileostomy may be necessary. The blood-urea level is 60 mg. per cent.

*Case* 1005.—Mr. G., aged 65. This patient had a papilliferous transitional-celled carcinoma of the bladder. Previously in 1950 a papilloma had been excised and radon seeds implanted, but the tumour recurred and in February, 1953, a total cystectomy and ileal transplantation were done (*Fig.* 352). Convalescence was complicated by a transient leakage of urine from the abdominal incision, but he was discharged dry and well five weeks after the operation. Collection has been into an adhesive ileostomy bag and is satisfactory. Some fifteen months after

his operation he remains fit and he continues with his normal employment. There has been no sign of pyelitis. The intravenous pyelograms remain quite normal and the blood-urea level is 29 mg. per cent.

*Case* 1006.—Mr. G., aged 74. This patient was found to have an anaplastic carcinoma of the bladder involving the prostate. In April, 1952, total cysto-prostatectomy was performed with ileal transplantation

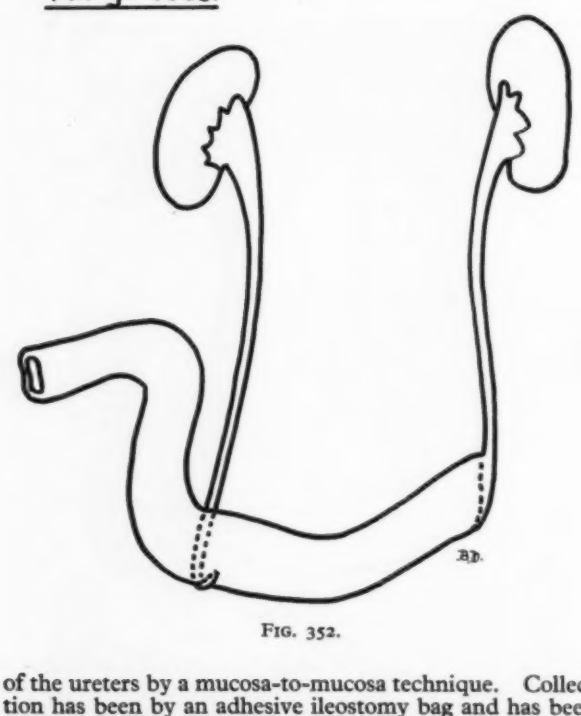



FIG. 352.

of the ureters by a mucosa-to-mucosa technique. Collection has been by an adhesive ileostomy bag and has been entirely satisfactory. The intravenous pyelogram—normal before operation—has remained so, and the blood-urea one year after operation is 31 mg. per cent. There have been no evidences of pyelitis.

At a recent follow-up the patient was well from the point of view of the ileostomy, but there is clinical and radiological evidence of secondary metastases in the lumbar vertebræ.

*Case* 1007.—Mr. C., aged 67. This man had had repeated fulguration to a papilliferous carcinoma of the bladder. When fulguration no longer controlled the growth he had a total cystectomy in April, 1953. Apart from leakage of urine from one uretero-ileal anastomosis which lasted only a few days, convalescence was uneventful. Collection of urine was easily managed with an adhesive bag. On discharge from hospital the man was well and the intravenous pyelogram, normal before operation, had remained so. The blood-urea level was 28 mg. per cent. This man had had a number of coronary attacks and had auricular fibrillation. He died suddenly two months later of a coronary thrombosis.

*Case* 1008.—Mr. S., aged 35 years. This man was found to have a diffuse papilliferous condition of his bladder, which on section was shown to be an invasive transitional-celled carcinoma. An intravenous pyelogram showed a horse-shoe kidney, but the renal pelves were not dilated. In July, 1953, he had a total cystectomy and ileal transplantation, and made an uneventful recovery. Collection of urine had been into an adhesive ileostomy bag of his own design and is very satisfactory. At 'follow-up' ten months after his operation he was in excellent health, the intravenous pyelogram remains unchanged, and the blood-urea level is 31 mg. per cent. There has never been an attack of pyelitis.

*Case* 1009—Mrs. B. This patient, aged 73, had multiple papilliferous tumours of the bladder which on section were shown to be transitional-celled carcinoma. In November, 1953, she had total cystectomy and transplantation of the ureters to an ileal loop. Indwelling polythene tubes were used across the lines of anastomosis. Apart from a very slight leakage of urine convalescence was normal. Collection of urine is into an adhesive ileostomy bag. Two months later she was in excellent health. The intravenous pyelograms were normal and the blood-urea was 38 mg. per cent. There has been nothing to suggest pyelitis.

*Case* 1010.—Mr. R., aged 80. This old gentleman had had papilliferous carcinoma of the bladder treated by fulguration and later by suprapubic diathermy excision and the tumour had recurred. In December, 1953, total cystectomy and ileal transplantation were done, using a direct elliptical anastomosis. Convalescence was complicated by wound dehiscence, but when this was resutured he went on to recovery. Collection has been into an adhesive bag which, though he needs assistance in tending it, is satisfactory. A recent blood-urea estimation two months after his operation was 31 mg. per cent. There has been no evidence of pyelitis.

*Case* 1011.—Mr. V., aged 55. This patient was found to have an ulcerating infiltrating carcinoma of the bladder, In March, 1954, total cystectomy and ileal transplantation were done, using indwelling ureteric tubes. Convalescence was complicated by a prolongation of ileus after the operation, but this was overcome by non-operative measures. Two months after the operation function has returned to a previously non-functioning kidney, but the other hydronephrotic kidney is slightly more dilated. Collection is into an adhesive ileostomy bag and is satisfactory. The most recent blood-urea estimation was 38 mg. per cent.

Six other cases have recovered from the operation, but have been done so recently that only a brief account of their progress is given in this paper.

*Case* 1012.—Mr. P., aged 55. This patient had a large palpable carcinoma of the base of the bladder. I.V.P. showed an absence of function of the right kidney and hydronephrosis of the left one. Total cystectomy and ileocutaneous ureterostomy were done on Feb. 9, 1954, the left dilated ureter being anastomosed end-to-end with the ileum. Discharge from hospital April 9.

*Case* 1013.—Mrs. McD., aged 64. Bimanual examination revealed a carcinoma of the right side of the bladder. Intravenous pyelography showed normal kidney function and normal appearances. On April 13, 1954, total cystectomy and ileocutaneous ureterostomy were done. The patient made a good recovery.

*Case* 1014.—Mrs. McM., aged 65. A cystostomy two weeks before she came to us revealed an extensive carcinoma of the bladder. Cystectomy and ileal transplantation of the ureter were done on April 27, 1954. Convalescence was complicated by small-intestinal obstruction requiring jejunostomy. The jejunostomy was closed later. An intravenous pyelogram before operation showed no function of the left kidney. Six weeks later function had returned to this kidney.

*Case* 1015.—Mr. D., aged 49. A papilliferous growth occupied most of the bladder in this case. Bimanual examination revealed a mass the size of a cricket ball.

Total cystectomy and ileal transplantation were done on June 1, 1954. He made a good recovery. A recent blood-urea is 44 mg. per cent.

*Case* 1016.—Mr. W., aged 56. This patient had a total cystectomy and ileocutaneous ureterostomy for a large papilliferous neoplasm of the bladder on April 6, 1954. Convalescence was interrupted by wound dehiscence that required resuture.

*Case* 1017.—Mr. McG., aged 54. Cystoscopy showed an extensive nodular growth of the bladder. An intravenous pyelogram showed a normal appearance of the left kidney. The right kidney did not show any function. There was a large filling defect in the bladder. Total cystectomy and ileal transplantation of the ureters were done on June 21, 1954. Convalescence was smooth after a short period of ileus.

## 2. ILEOCUTANEOUS URETEROSTOMY FOR HYDRONEPHROSIS FOLLOWING TUBERCULOUS CONTRACTURE OF THE BLADDER

Only one patient has had this operation, but it is in many ways the most dramatic of the series.

*Case* 1022.—Mr. T. H., aged 38 years, had a nephrectomy for tuberculosis of the kidney in 1945, immediately following which he developed urinary fistulæ from the incision and from multiple openings on the perineum and in the groins. Until February, 1952, when we saw him, he had lived wrapped up in towelling, most of the time in bed. He was thin and pale and had not been able to return to his work since his operation. An intravenous pyelogram at that time showed gross hydronephrosis of a single remaining kidney, with ureteric dilatation down to a small contracted bladder.

At operation (W. R. H.) in February, 1952, the dilated ureter was divided and sutured end-to-end to an isolated ileal loop, the other end of which was brought out through a skin-covered spout (*Fig.* 353). The fistulæ dried up immediately and healed within two weeks. Urine has been collected in a non-adhesive ileostomy bag and he remains dry. Two years later he is fit, has gained 1½ st. in weight and does a full day's work. A recent intravenous pyelogram taken shows some diminution in the degree of hydronephrosis and the blood chemistry is normal. The blood-urea level is 35 mg. per cent.

This patient is in every way delighted with the result of his operation.

It might have been possible to have achieved the same result more simply by doing a ureterostomy, perhaps with a skin-grafted nipple as described by Band (1942), but our experience of this operation does not recommend it to us. Too frequently the ureter has sloughed at its tip to disappear deeply into a cleft and also stenosis seems specially liable to occur at the uretero-cutaneous junction. These complications demand the use of an indwelling catheter for collection and this has been found to result in renal infection and destruction similar to that seen after ureterocolic anastomosis.

We feel that in our patient the freedom from renal infection and the arrest, if not the reversal of hydronephrosis, has been sufficient compensation for the little inconvenience that a urine-draining ileostomy has caused him.

A more detailed consideration of the renal and biochemical effects of the operation in this case comes later in the paper.

This operation would seem to have a place where progressive renal distension is occurring in a remaining kidney due to ureteric stenosis or when the patient suffers the intolerable frequency of micturition associated with a 'thimble' bladder. Under these conditions it has been the general practice to advise ureterocolic anastomosis. When one kidney has already been removed it becomes especially important to preserve all remaining renal tissue, and we know that where a dilated ureter has to be transplanted the result of the ureterocolic anastomosis is especially bad. Many of these patients are young and in the majority the active tuberculous process has healed. Our experience in this case encourages us in the belief that ileocutaneous ureterostomy offers a better chance of preventing further renal destruction. We have knowledge of two other successful cases dealt with in a similar fashion. Alternatively some of these cases may offer opportunities for enlargement of the bladder and simultaneous drainage of the kidney by an ileal loop.

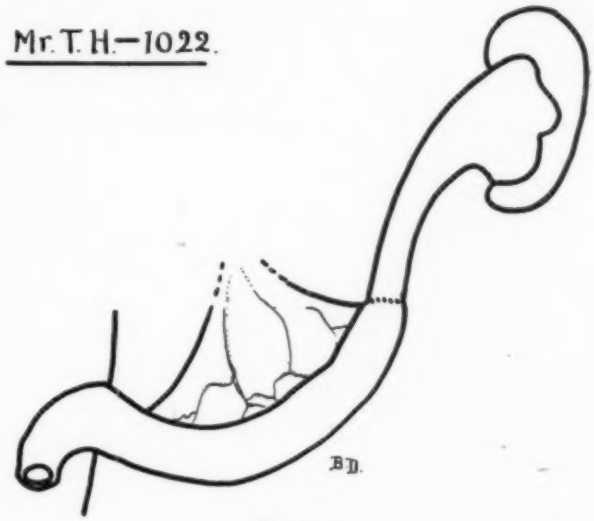



FIG. 353.

## 3. ILEOCUTANEOUS URETEROSTOMY FOR MALIGNANT VESICOVAGINAL FISTULA

Four cases of vesicovaginal fistula were treated. Two fistulæ followed radium treatment for carcinoma of the cervix uteri, one followed radium for carcinoma of the body of the uterus, and the fourth resulted from the direct invasion of the bladder by a carcinoma of the vagina in a complete procidentia. It was manifest that attempts at local repair would have been of no avail, and the operation of ileo-cutaneous ureterostomy was done as an alternative to ureterocolic transplantation.

*Case* 1018.—Mrs. M., aged 51. This patient had a subtotal hysterectomy in 1944 and developed carcinoma of the cervical stump in 1952, which was treated with radium. Following irradiation she developed a recto-vaginal fistula, which required a colostomy for its relief. Shortly afterwards she developed a vesicovaginal fistula. Both ureters were transplanted into an isolated ileal loop in July, 1953. Some difficulty was encountered at first

in collecting urine from the flush ileostomy, but with an adhesive bag the condition is now satisfactory and she is greatly improved. A recent intravenous pyelogram nine months after her operation shows normal appearances of both kidneys. The blood-urea level is 20 mg. per cent. There has been no evidence of pyelitis.

*Case* 1019.—Mrs. J. M., aged 68. This patient had had a complete procidentia for many years. She developed a carcinoma of the vault of the vagina which eroded the bladder. She was admitted with evidence of uræmia and with marked abdominal distension. After a long pre-operative preparation the ureters were implanted into an isolated loop of small intestine in December, 1952. Her immediate post-operative progress was satisfactory but she died of cardiac failure one month later.

*Case* 1020.—Mrs. D., aged 55. In 1952 this patient had radium treatment for carcinoma of the cervix uteri. Early in 1954 she developed a vesicovaginal fistula which was large enough to admit two fingers. There was considerable induration but no ulceration. On April 2, 1954, the ureters were implanted into an isolated length of ileum. The ileostomy was of the ' mucosal button ' type. Very little urine drained from the polythene tube in the right ureter and two days later it was pulled out. Urine then drained freely from both ureters. An intravenous pyelogram fifteen days after her operation showed good function of both kidneys, but there is some slight pelvic dilatation. The blood-urea is now 47 mg. per cent and the $CO_2$-combining power 48 vol. per cent. She manages the adhesive collecting apparatus without difficulty.

*Case* 1021.—Mrs. L., aged 62. This patient had a carcinoma of the body of the uterus which was treated with radium in 1948. Soon after she developed a vesicovaginal fistula. Three attempts were made at operative closure of this fistula but all failed, and when we saw her she had a large vesicovaginal fistula. Biopsy of the edge showed adenocarcinoma. A palliative ureteric transplantation was contemplated, but at operation an unsuspected carcinoma of the pelvic colon was discovered. Both the original tumour and the colonic neoplasm seemed removable. A resection of the pelvic colon with end-to-end anastomosis was done and the ureters were transplanted into an isolated ileal loop. This patient weighed 15 st., was immensely fat, and had been confined to bed for twelve months before her operation. She had emphysema and chronic bronchitis. She died of bronchopneumonia following a second operation for the closure of a burst abdomen.

Our experience of these four cases has been discouraging, but in retrospect the two patients who died were difficult complicated cases and we feel that for a vesicovaginal fistula following either injury or the use of radium to the cervix, where simpler measures of closure have failed and ureteric transplantation is contemplated, ileocutaneous ureterostomy may be the operation of choice.

We might add here an account of a patient for whom radium treatment had been applied to the cervix ten months earlier. She became increasingly ill and was re-admitted. At that time a large mass was felt at the upper end of the vagina. When she was seen by us she had passed no urine for four days. She had passed only 3 oz. of urine during the previous three days. She was in coma and the blood-urea was 222 mg. per cent. Ileocutaneous ureterostomy was performed to relieve the ureteric obstruction and immediately she began to secrete urine. In three days the blood-urea level had fallen to 45 mg. per cent and she continued to pass normal quantities of urine until she died some weeks later, the result of extensive metastasis.

## 5. ILEOCUTANEOUS URETEROSTOMY FOR URETHRAL STRICTURE AND PERINEAL FISTULÆ

One case is recorded.

*Case* 1027.—Mr. Y., aged 38. This patient was injured whilst in the Forces in 1943. He had a fractured pelvis and a rupture of the urethra, and was treated by catheter drainage. He was first seen by us five years later when he was admitted with acute retention. Suprapubic cystostomy was done and later the stricture was dilated. Two years later the suprapubic wound was still leaking and it was closed surgically. Radiographs showed a stricture well back in the membranous urethra. The urine was then infected. He was having dilatations every 3-4 weeks. During the following year there were repeated attacks of severe cystitis, and in December he had a further attack of retention. In April, 1952, he was admitted with periurethral abscesses and a urinary fistula in the perineum.

This state of affairs had continued with more frequent bouts of pyrexia, and after dilatation he was incontinent and was leaking urine from the perineum.

April 10, 1954: I.V.P., Right kidney shows good activity. The left kidney concentrated badly and a poor outline of the pelvis was seen. Pre-operative urea was 30 mg. per cent. It was agreed that only some form of deviation of the urine, either by suprapubic drainage or ureteric transplantation would help him. Urethral repair was carefully considered in consultation and decided to be impossible.

April 30, 1954: OPERATION: Both ureters were implanted into an isolated loop of small bowel by a Coffey type procedure. He made an excellent recovery and manages his ileostomy bag without difficulty. The blood-urea level is 35 mg. per cent and the fistulæ have healed. The man is well-satisfied and has returned to normal activity.

## 4. ILEOCUTANEOUS URETEROSTOMY IN THE SURGICAL TREATMENT OF EXTENSIVE PELVIC CARCINOMA

From time to time a carcinoma of the rectum is encountered which is inoperable according to the accepted method by the combined abdominoperineal operation because it is adherent to the prostate or to the bladder, or both. If this is the only bar to its removal the excision may be widened to include the prostate and bladder and perhaps part of the membranous urethra with the rectal excision. This means that the urinary flow must be diverted. Such a case is included in this series.

*Case* 1028.—Mr. B., aged 66 years. In January, 1954, this man was found to have a carcinoma of the rectum involving the prostate and urethra. The patient was in some pain and there was blood and discharge from the anus. A left iliac colostomy was done as a palliative measure. At this stage the patient came under our care and it was decided that, if there were no secondary deposits in the liver and the growth was operable at operation, we would deviate the urine and later do a synchronous combined excision.

At laparotomy the liver appeared free of secondary deposits and there was no evidence of involvement of the peritoneal cavity. The ureters were implanted into a loop of small bowel and some four weeks later the rectum, bladder, prostate, and membranous urethra were excised. The latter operation, conducted after these preliminary measures, presented certain difficulties.

When the left ureter was implanted into the isolated loop of small intestine, it was passed through the pelvic mesocolon from left to right behind the inferior mesenteric artery. At the time of the excision of the pelvic colon and rectum, the dissection to free the mesocolon and ligate the artery was a tedious and difficult procedure, and there was constant concern lest the left ureter should be damaged or the implantation into the small intestine be disturbed.

In any future case, if the patient is sufficiently fit, we would do the operation in one stage. It is possible, however, that some patients suitable for this procedure will not be fit to stand such a long operation and perforce we shall be obliged to conduct the operation in stages. If a staged method is used the obvious way would be to fashion the colostomy and implant the ureters at the same time, but this would still leave the difficult dissection of the inferior mesenteric artery in the region of the left ureteric implant at the second stage. Next time we shall probably excise the redundant piece of pelvic colon and turn in the rectal stump just above the pelvic floor at the first stage. This would make the second stage a much simpler procedure.

The patient is very well and is able to manage a belt that has been made to hold a colostomy plate on the left side and an ileostomy bag on the right. This collecting apparatus is by no means the burden that it might seem.

There has been no evidence of renal infection and the blood-urea is 40 mg. per cent.

## THE EFFECTS OF ILEOCUTANEOUS URETEROSTOMY UPON THE KIDNEYS AND THE ASSOCIATED BIOCHEMICAL CHANGES

The operation of ileocutaneous ureterostomy will be finally judged on whether or not it results in a lesser degree of renal destruction than is known to occur following ureterocolic anastomosis. Ureterocolic anastomosis causes renal damage from progressive dilatation of the renal pelvis together with pyelonephritis, and these are the things that we have sought to overcome by ileocutaneous ureterostomy.

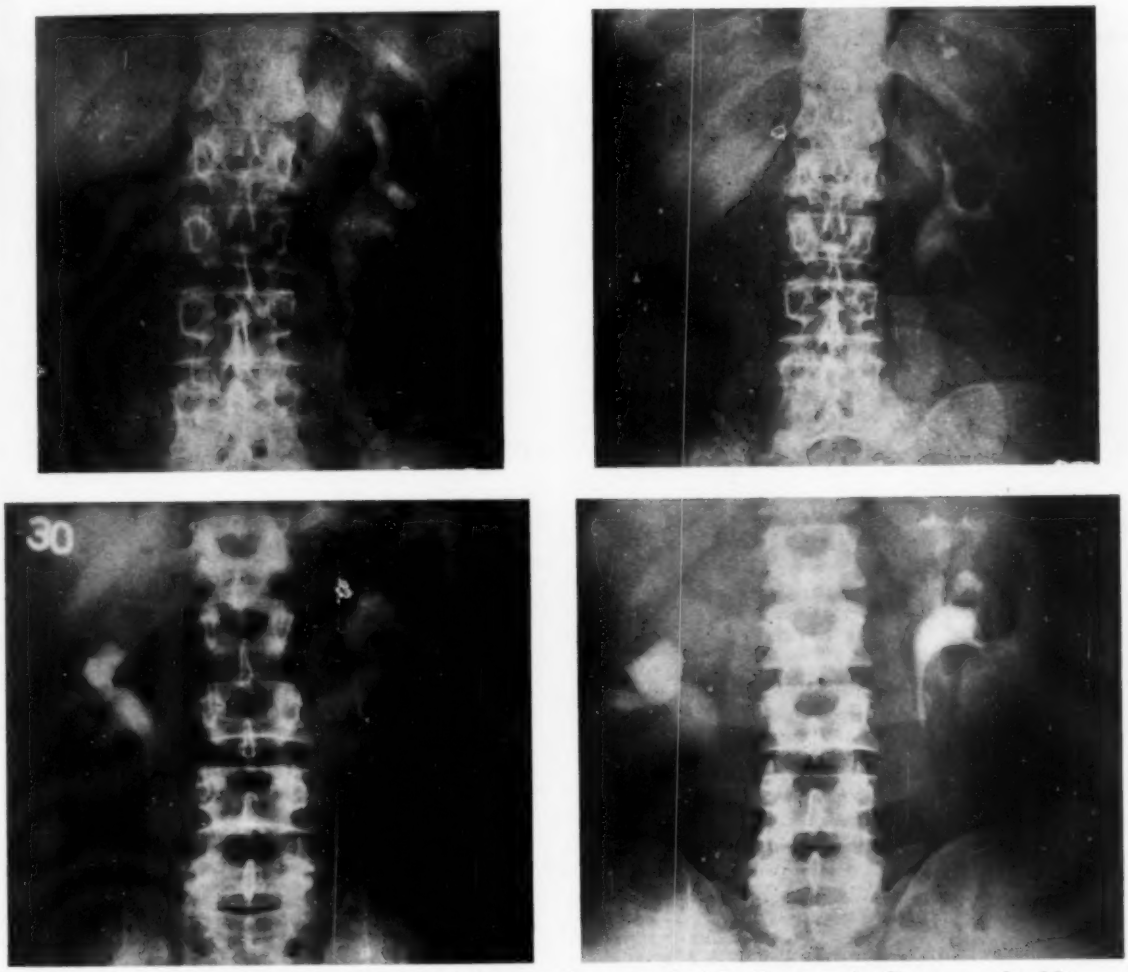



FIG. 354.—Some typical pyelograms. Films before operation are on the left. Post-operative films are on the right.

It is impossible to estimate renal function with any degree of accuracy by the usual clearance methods in a patient who has had any form of ureterointestinal anastomosis, because of the difficulties of accurate collection and because of the unknown factors of reabsorption and secretion from the intestinal mucosa. We have, therefore had to rely on the clinical, biochemical, and radiological evidences.

Twenty-two patients are available for study, but of these 7 have been operated upon quite recently and have not been included in this survey though the early findings in these unrecorded cases show no

divergence from the behaviour of those reviewed. The remaining 15 patients have been followed up for periods varying from 27 months to two months.

**Clinical Progress.** — Since discharge from hospital no patient has complained of loin pains, chills, or fever suggestive of renal infection, nor has health been impaired through imperfect urinary excretion.

**Radiological Evidence.**—Most of these patients have had intravenous pyelograms at six-monthly intervals. In 14 of the 15 patients, comparative pre- and post-operative pyelograms are available. For the 15 patients twenty-eight ureters have been transplanted. *Table I* shows the changes which have occurred following ileocutaneous ureterostomy.

*Table I.*—Renal Changes in 28 Transplanted Ureters

| Pre-operative Condition | Post-operative Condition at Last Follow-up |
|---|---|
| 18 normal pyelograms<br>2 presumed normal | 15 remain normal<br>3 show slight dilatation<br>2 normal |
| 4 slightly dilated renal pelvis | 1 returned to normal<br>3 show slight increase |
| 1 grossly dilated renal pelvis | 1 showed diminution in size |
| 3 radiologically non-functioning kidneys | 3 showed return of function |

It will be seen that eighteen kidneys had normal pyelograms. Of these, fifteen have remained normal and three have shown very slight pelvic dilatation, though the minor calices are not affected. In addition two kidneys for which the pre-operative intravenous pyelograms are not available are now quite normal.

Four kidneys showed slight dilatation before operation, and of these one shows a return to a normal appearance while three show some slight increase in the dilatation. One of these began to dilate some sixteen months after the operation, and this coincided with a partial obstruction at the ileocutaneous junction. One grossly dilated ureter was transplanted and there has been a diminution in the size of the pelvic outline. Three kidneys that showed no shadow on intravenous pyelography before the operation have all shown a gradual return of function during the subsequent months.

These results are similar to those reported by Bricker (1952), who analysed the changes in pelvic outline in 28 patients. Fifty-five ureters were transplanted and thirty-nine were found later to be entirely normal or only very slightly dilated. In addition, all the kidney pelves showing dilatation before the operation showed some diminution in size after it. Bricker summarizes his results by saying that where there had been no renal damage before operation the operation had not caused it and where damage had already occurred the operation had usually improved it.

**Biochemical Changes.**—A full biochemical analysis of the blood has been carried out at each follow-up visit, and *Table II* shows the changes that have occurred and records the latest blood chemistry estimations for 21 patients. It will be seen that the blood-urea levels are with three exceptions within the limits of the normal. In these three exceptional cases two have blood-urea levels of 60 mg. per cent and the third 70 mg. per cent. The last patient is a woman of 74 years and only recently has the blood-urea level risen.

*Table II.*—Blood Chemistry at the Latest Follow-up in Patients who have had Ileocutaneous Ureterostomies

| Patients | Blood-urea | $CO_2$-combining Power | Serum-Na | Serum-K | Serum-Cl (as NaCl) |
|---|---|---|---|---|---|
| | mg. per cent | vols. per cent | mEq/l | mEq/l | mEq/l |
| 1 | 48 | 45 | 130·5 | 6·67 | 97·5 |
| 2 | 35 | 56 | 147·8 | 3·97 | 100·5 |
| 3 | 70 | 51 | 141·3 | — | 98·2 |
| 4 | 35 | 48 | 126·2 | 4·70 | 97·8 |
| 5 | 29 | 58 | 141·3 | 3·90 | 105·7 |
| 6 | 29 | 49 | 143·5 | 4·23 | 96·0 |
| 7 | 28 | 42 | 145·6 | 5·10 | 112·6 |
| 8 | 31 | 50 | 141·3 | 3·70 | 98·6 |
| 9 | 38 | 58 | 147·8 | 4·23 | 105·1 |
| 10 | 31 | 46 | 147·8 | 4·89 | 98·8 |
| 11 | 36 | 53 | 126·2 | 4·89 | 85·3 |
| 12 | 20 | 49 | 141·3 | 4·74 | 104·3 |
| 13 | 60 | 48 | 130·5 | 5·00 | 113·2 |
| 14 | 35 | 58 | 121·7 | 5·51 | 90·2 |
| 15 | 60 | 40 | 123·9 | 3·33 | 94·3 |
| 16 | 30 | 52 | 130·5 | 3·90 | 91·6 |
| 17 | 35 | 56 | 134·8 | 4·89 | 100·1 |
| 18 | 40 | 60 | 117·4 | 4·35 | 90·5 |
| 19 | 47 | 48 | 145·6 | 4·89 | 108·5 |
| 20 | 44 | 74·5 | 134·8 | 4·10 | 99·6 |
| 21 | 34 | 46·2 | 152·2 | 3·07 | 99·1 |

Of special interest are the figures for $CO_2$-combining power. Most of these estimations show levels that are either at or slightly below the lower limits of the normal range. The serum-chloride levels are, with four exceptions, within the limits of the normal, though some of the figures are approaching the upper limits of the normal range. Thus it will be seen that some patients in common with patients who had ureterocolic anastomoses have a slight tendency towards a laboratory hyperchloræmic

acidosis. The serum-sodium and serum-potassium levels are, with three or four exceptions, within the normal range.

## 6. THE REPLACEMENT OF A LENGTH OF DAMAGED OR DISEASED URETER BY A SEGMENT OF ILEUM, WITH RESTORATION OF CONTINUITY BETWEEN THE RENAL PELVIS AND THE BLADDER

There have been occasional reports, both experimental and clinical, in which small intestine has been used to replace a length of ureter. Most authors have stressed that this operation should be used only when simpler measures of ureteric repair have failed or are manifestly impracticable.

Most of the cases required ureteric repair because of accidental injury to the ureter, although occasionally involvement of the ureter in some adjacent pathological process may call for a wide excision. Restoration of continuity using ileum is done in these cases as a direct alternative to nephrectomy.

For the restoration of ureteric continuity ileum has many favourable qualities. It is available in sufficient length to bridge almost any gap in the ureter, it has its own propulsive activity, and it can be anastomosed easily both to the ureter and to the bladder. The main theoretical disadvantage is that absorption of urinary constituents might occur from its epithelial lining. Doubtless some absorption must occur, but there is sufficient experimental and clinical evidence to make it certain that it has no untoward clinical implications.

Our experiments in dogs in which they survived, in good health, for the duration of the experiment (12 months) with a single kidney attached by small intestine to the urinary bladder, together with clinical reports of its successful use, encouraged us to adopt this method for two patients. The details of a third case (*Case* 1030) have been given to us by Professor F. E. Stock of Hong Kong.

*Case* 1029.—Mr. L., aged 69. In September, 1953, she had a total hysterectomy for adenocarcinoma of the uterus. Soon after her discharge from hospital she developed a uretero-vaginal fistula and an intravenous pyelogram showed the presence of a dilated left ureter (*Fig.* 355). In November, 1953, an operation was undertaken to close this fistula, but the lower end of the ureter was embedded deeply in inflammatory mass. A length of small intestine was isolated about 12 in. from the ileocæcal valve and intestinal continuity was restored by side-to-side anastomosis. The upper end of the isolated loop was anastomosed end-to-end with the ureter and the lower end was implanted into the fundus of the bladder. The patient made an uninterrupted recovery and ten days later an intravenous pyelogram showed normal appearance of both kidneys (*Fig.* 356). A cystogram shows that reflux into the ileal loop occurs momentarily only during the act of micturition. The blood chemistry is normal; the blood-urea level is 25 mg. per cent, and the alkali reserve is 51 volumes per cent.

FIG. 355.—Pre-operative intravenous pyelogram showing left-sided hydronephrosis.

FIG. 356.—Intravenous pyelogram ten days after ileal replacement of the left ureter.

*Case* 1030.—Mrs. M., aged 65. This patient had a total hysterectomy for endometriosis and difficulty seems to have been encountered in securing hæmostasis. Ten days after this operation intestinal obstruction developed at which time the pelvic colon was found to be grossly thickened and adherent to the new pelvic floor. Transverse colostomy was done. Three days later a second operation had to be performed, at which time a large collection of urine was observed extraperitoneally, and this was drained. Convalescence was satisfactory, but later an intravenous pyelogram demonstrated a functioning left kidney with extraperitoneal extravasation. At the third operation the left ureter was identified where it entered an inflammatory mass at the pelvic brim. The ureter was divided and a bridge of small intestine used to

connect it to the dome of the bladder (*Fig.* 357). Convalescence was satisfactory and later the colostomy was closed. A recent intravenous pyelogram demonstrated satisfactory function of the left kidney with slight hydronephrosis.

*Case* 1031.—D. P., aged 65. This patient had carcinoma of the pelvic colon extensively involving the left ureter. An excision of the pelvic colon with end-to-end anastomosis was performed, and this excision included so much of the ureter that it was impossible to restore the continuity by mobilization and suture. The upper end of the divided ureter was implanted into an isolated length of ileum and the lower end brought out as an ileostomy. The patient made an uninterrupted recovery. We intended to re-implant the lower end of the ileal loop into the bladder at a later date, but the patient expressed himself content with the adhesive ileostomy bag and he continues to use it. The operation was done in September, 1952, and in March, 1954, he was reasonably well although there had been some troublesome excoriation around the ileostomy which, however, had cleared up spontaneously. On one occasion he passed a small calculus from the ileostomy. The most recent intravenous pyelogram shows a normal appearance of both kidneys.

FIG. 357.—Retrograde pyelogram showing ideal replacement of a length of ureter (ten days after operation).

A report of Baum, of the University of Michigan (personal communication, 1953) of a very satisfactory outcome in 5 cases similar to our own is of interest. By radiographic studies he showed that the introduction of fluid into the ileal ureter resulted in its very rapid transit to the bladder, and this has also been our own experience. Whilst reflux occurs into the ileal ureter during the act of micturition it is followed by equally rapid emptying of the ileal ureter into the bladder. Baum also points out that this reflux may be less damaging to the kidney because the distensible ileum may cushion the increasing pressure.

## 7. THE USE OF ISOLATED ILEAL LOOP TO INCREASE THE CAPACITY OF A CONTRACTED BLADDER

Couvelaire (1950) has described the successful use of ileum to increase the capacity of a contracted bladder. We have one such case to report.

*Case* 1032.—Mr. C., aged 21. This patient had had a left nephrectomy and a transvesical seminal vesiculectomy in November, 1949. When we saw him he had developed a rectovesical fistula, the troublesome frequency of micturition persisted, and he was passing urine every half hour. An intravenous pyelogram showed that the remaining kidney was healthy and the ureter was of normal diameter. The bladder was small and contracted. At operation on April 2, 1954, the rectum was separated from the bladder and the fistula was effectively closed. A loop of ileum about 6 in. in length was isolated and its ends were closed. It was anastomosed side by side to the bladder, leaving a wide opening between them. His post-operative course was uneventful and even now there is considerable symptomatic improvement. A cystogram shows that the ileal 'diverticulum' fills when fluid is injected into the bladder and that it empties completely during micturition, though this required some voluntary effort from the patient.

## DISCUSSION

We have been concerned with the use of a loop of ileum in the urinary tract (*a*) as a method of bringing the urinary stream to the skin surface for collection after transplantation of the ureters; (*b*) as a method of reconstruction of the ureter; (*c*) as a means of enlarging the bladder.

**Technique.**—Technically, all the procedures described are within the competence of the experienced surgeon, although we have found that total cystectomy with transplantaton of the ureters in one stage, already a lengthy and tiring procedure, is indeed burdensome when resection and re-anastomosis of the ileum are added. Modern anæsthesia enables the patient to withstand the long operation and the surgeon may best serve the interests of his patient by having a competent assistant to take over selected stages of the operation.

The vertical *incision* in the lower abdomen, whether median or paramedian, especially in fat patients, is liable to break down and is probably better avoided. As an alternative, a transverse approach by one of the accredited methods may be preferred. In our hands, however, this also has meant delayed healing after total cystectomy if the rectus has been cut across. Possibly the most satisfactory is an incision passing obliquely upwards and outwards from the symphysis pubis, with division of the anterior rectus sheath in this direction and lateral displacement of the rectus muscle. In women vaginal drainage is a great help, and in men perineal drainage may be employed for the large pelvic cavity left after the cystectomy.

Since for the reasons stated we are utterly opposed to the whole concept of ureterocolic anastomosis, it is no part of our task to describe in detail the many methods that have been devised except in so far as they are of use to us in our own procedures. To anastomose ureter to ileum we have made use of: (*a*) the simple method similar to Stiles (W. R. H.); (*b*) the open method of Nesbit; and (*c*) the tubed method of Kidd, Coffey, and others. Theoretically the mucosa-to-mucosa suture of Nesbit should give the best immediate and late results, but it is time-consuming in an already long operation and we had abandoned it in total cystectomy for this reason and because in three cases we have had trouble from leakage. It is the method of choice if the ureter is dilated, as in old tuberculous cases, and, if one can give the time to it, it is really the best technique so far devised. The tubed method is very convenient for post-operative collection of specimens and allows of individual renal function studies for a time. However, our experience with some recent cases suggests that the nipple-like ureteric ends in the ileal loop may cicatrize with a tendency towards stenosis at a later date. The simple Stile's technique is favoured by two of us and has given good results with few troubles early or late.

The after-care of the total cystectomy group also calls for some comment. A degree of ileus commonly follows the operation owing, no doubt, to extensive handling, ileal anastomosis, and the denuding of the anterior surface and trauma to the lateral borders of the rectum. The last of these may be the most important, and in some of our cases a rectal tube has been inserted before the operation, pushed up from below into the sigmoid colon before closure of the abdomen, and left in situ for a few days. Fluid by mouth may not be tolerated for five days to a week, and until the ileus is overcome parenteral feeding is employed. To attempt to force fluids may aggravate the tendency towards intestinal distension; rather should a Ryle's tube be kept in position and the stomach aspirated as required until the ileus is overcome. Gastric suction and intravenous fluid call for careful electrolyte and water regulation, and unless this can be provided work of this character should not be attempted.

In vesical enlargement and ureteric replacement the kidney or kidneys are not exposed to any great risk of back-pressure or infection, and our chief concern was to know whether the ileal loop was going to prove functionally convenient and biochemically safe. The functional inconvenience of excessive mucous secretion has been mentioned by some writers but has not troubled us in our experimental animals or in any of our patients, although the presence of mucus has always been obvious enough. Nor have we found any evidence of gross biochemical changes resulting from the passage of the urine through the ileal loop. In this connexion, our experiments in dogs described in detail elsewhere (Annis, 1953) suggested that gross electrolyte imbalance was improbable and this has been confirmed by the experience of our patients. Baum is of similar opinion (personal communication). He could find no gross evidence of electrolyte imbalance in his five cases, although the $CO_2$-combining power in one of his cases was slightly lowered. This slight tendency towards hyperchloræmic acidosis in his case, together with a similar tendency in some of our ileocutaneous ureterostomies, suggests that some electrolyte absorption from the ileum does occur, though it is controlled by adequate renal compensation. It is possible that serious acidosis has not occurred in our cases, more because the operation preserves good renal function than because of any lesser absorption of acid radicles. That the nature of the absorption from ileum is different from that in the colon and less likely to result in hyperchloræmia and acidosis, is, however, suggested by our observation that the ileal efflux of urine is frequently neutral or slightly acid. This contrasts markedly with what we know of the urinary loss in ureterocolic anastomosis. Here the urine is usually alkaline, although some of this alkalinization may be due to the splitting of urea by organisms in the bowel in addition to absorption of acid radicles. Much of this work is made difficult because of the inability accurately to assess renal function, after transplantation of the ureters into the bowel has allowed re-absorption and excretion to modify the final urinary loss.

We are of the opinion that a length of small intestine can be isolated and used to replace the diseased or damaged ureter when simpler methods are impracticable or have failed. The theoretical objection that urinary waste products might be absorbed from this intestinal loop seems to have no practical implication. Thus in one of our cases a single grossly dilated kidney was connected to an intestinal loop without resulting in any abnormality of the blood-electrolyte or blood-urea levels.

Ileocutaneous ureterostomy should be used whenever permanent drainage of urine to the skin surface is contemplated. This is especially necessary when bilateral ureterostomy is considered, for it allows of a single manageable opening. The interposition of ileum between ureter and skin allows of free urinary drainage without indwelling collecting apparatus and seems to prevent ascending renal infection.

## SUMMARY

A short length of ileum has been used as a conduit for urine in a variety of circumstances. Its suitability has been demonstrated both experimentally and clinically. Thirty-five case reports of patients who had small intestine used in this way are recorded.

The main uses have been :—

1. To direct urine to an external collecting bag following total cystectomy for carcinoma of the bladder as an alternative to ureterocolic anastomoses. We report on 21 cases, and in addition there were 2 cases where we could not go on to total cystectomy.

2. To collect urine externally in a patient who had progressively increasing hydronephrosis of a solitary kidney due to tuberculous contracture of the bladder.

3. To relieve an otherwise irreparable vesico-vaginal fistula as an alternative to ureterocolic anastomosis.

4. To replace a length of diseased or damaged ureter where simpler methods of repair are inapplicable and where nephrectomy or uretero-colic anastomosis is contemplated.

5. To increase the size of a contracted bladder.

In the fourth and fifth groups the operation has preserved or restored the normal channel of urinary excretion and has been in every way satisfactory. In the first three groups the operations have been done in circumstances demanding deviation of urinary flow, and these patients have borne the inconvenience of an external reservoir for the collection of urine as the price of freedom from progressive renal destruction.

The progress of these patients is recorded. All have learned how to use the collecting bag satisfactorily. Since discharge from hospital none has had an attack of clinically recognizable renal infection and only one has had transient symptoms that could possibly be interpreted as being due to mild acidosis.

Blood-urea levels have, in the main, remained within normal limits and apart from a mild biochemical acidosis and a slight hyperchloræmia in some patients the blood analyses have been normal. Preservation of renal substance as judged by intravenous pyelogram is far better than anything we have seen following ureterocolic anastomosis. The general health and well-being of these patients has been decidedly better than we have come to expect following ureterocolic anastomosis.

We are indebted to Miss Barbara Duckworth for the line drawings; to Mr. Wilfred Lee and the Staff of his Department for the photographs; and to Mr. Charles Bullen, of Liverpool, for making, modifying, and fitting the ileostomy bags.

## REFERENCES


ANNIS, D. (1952), *Proc. R. Soc. Med.*, **45**, 483.
— — (1953), *Brit. J. Urol.*, **25**, 69.
— — and ALEXANDER, K. M. (1952), *Lancet*, **2**, 603.
— — HUNTER, W. R., and WELLS, C. A. (1953), *Ibid*, **1**, 1172.
BAND, D. (1942), *Edinb. med. J.*, **49**, 273.
BAUM, W. C. (1953), personal communication.
BERG, J. (1907), *Nord. med. Ark.*, **1**, 1.
BRICKER, E. M. (1950), *Surg. Clin. N. Amer.*, **30**, 1511.
BRICKER, E. M. (1952), *Surgery*, **32**, 372.
CABOT, H., and SCHERER, R. G. (1935), *Ann. Surg.*, **102**, 849.
COUVELAIRE, R. (1950), *J. Urol. méd. chir.*, **56**, 381, 688.
— — (1951), *Ibid.*, **57**, 530.
DEAN, A. L. (1950), *J. Urol.*, **63**, 858.
FOLSOM, A. E., and O'BRIEN, M. A. (1941), *Ibid.*, **45**, 587.
GLASER, S. (1952), *Brit. J. Urol.*, **24**, 216.
HENDERSON, D. St. C. L. (1952), *J. Urol.*, **67**, 279.
HINMAN, F., and WEYRAUCH, H. M. (1936), *Trans. Amer. Ass. gen.-urin. Surg.*, **29**, 15.
JACOBS, A., and STIRLING, W. E. (1952), *Brit. J. Urol.*, **24**, 259.
KEYES, E. L. (1940), *J. Urol.*, **44**, 40.
— — (1943), *Ibid.*, **50**, 580.
KRÖNIG, B. (1907), *Zbl. Gynäk.*, **81**, 559.
LAPIDES, J. (1951), *Surg. Gynec. Obstet.*, **93**, 691.
LONGUET, Y. J. (1948), *Urol. cutan. Rev.*, **52**, 322.
MCLEAN, D. W., and FAIS, O. G. (1952), *J. Urol.*, **68**, 190.
MAKKAS (1910), *Zbl. Chir.*, **37**, 1073.
MATHÉ, C. P. (1944), *Trans. Amer. urol. Ass. W. Br.*, **12**, 41.
MATSUMOTO, M. (1938), *Arch. P. Jap. Chir.*, **15**, 45.
MERRICKS, J. W., GILCHRIST, R. K., HAMLIN, H., and RIEGER, I. T. (1951), *J. Urol.*, **65**, 581.
MERSHEIMER, W. L., KOLARSIK, A. J., and KAMMANDEL, H. (1950), *Bull. N.Y. med. Coll.*, **13**, 71.
— — — — — — (1951), *Proc. Soc. exp. Biol., N.Y.*, **76**, 170.
MILLIN, T., and MASINA, F. (1949), *Brit. J. Urol.*, **21**, 108
MÜLLER, K. (1950), *Arch. klin. Chir.*, **264**, 588.
NISSEN, R. (1940), *J. int. Coll. Surg.*, **3**, 99.
PARSONS, F. M., POWELL, F. J. N., and PYRAH, L. N. (1952), *Lancet*, **2**, 599.
POOL, T. L., and COOK, E. N. (1950), *J. Urol.*, **63**, 228.
PYRAH, L. N. (1954), *Ann. R. Coll. Surg.*, **14**, 169.
REMEDI, V. (1906), *Clin. chir., Roma*, **14**, 608.
SCHEELE, K. (1923), *Beitr. klin. Chir.*, **129**, 414.
TRABUCCO, A., and MARQUEZ, F. J. (1950), *Rev. argent. Urol.*, **19**, 201.
ULITZCH, K. (1949), *Z. Urol.*, **42**, 335.
VERHOOGEN, J., and de GRAEVA, A. (1909), *Folia urol., Lpz.*, **3**, 629.
WELLS, C. A. (1951), *Brit. J. Med.*, **1**, 1082.
— — (1952), *Brit. J. Surg.*, **39**, 309.


# SACRALIZATION: AN AETIOLOGICAL FACTOR IN LUMBAR INTERVERTEBRAL DISK LESIONS, AND A CAUSE OF MISLEADING FOCAL SIGNS

By JOHN ANDREW

THE DEPARTMENT OF NEUROSURGICAL SURGERY, ST. BARTHOLOMEW'S HOSPITAL, LONDON

THE frequency of congenital abnormalities of the lumbosacral spine in the radiographs of patients suffering from lumbar intervertebral disk protrusions has been noted by several authors. These abnormalities include spondylolysis, spina bifida, and sacralization. A further variation—namely, occult sacralization—has been described by O'Connell (1951). Here the sacrum is high in the pelvis, and the spinous process of the last lumbar vertebra may be level with, or just below, the iliac crests. The lumbar spine shows five vertebræ, but the sacrum may be composed of six vertebral segments. As these are not cases of frank sacralization of the fifth lumbar vertebra, the term 'occult sacralization' has been used to describe the abnormality. It is believed that the recognition of both frank and occult sacralization is of importance. In the first place these two conditions may predispose to intervertebral disk protrusions; in the second place the neurological symptoms and signs may be at variance with those expected from a cursory examination of the radiographs, as well as with the findings at operation.

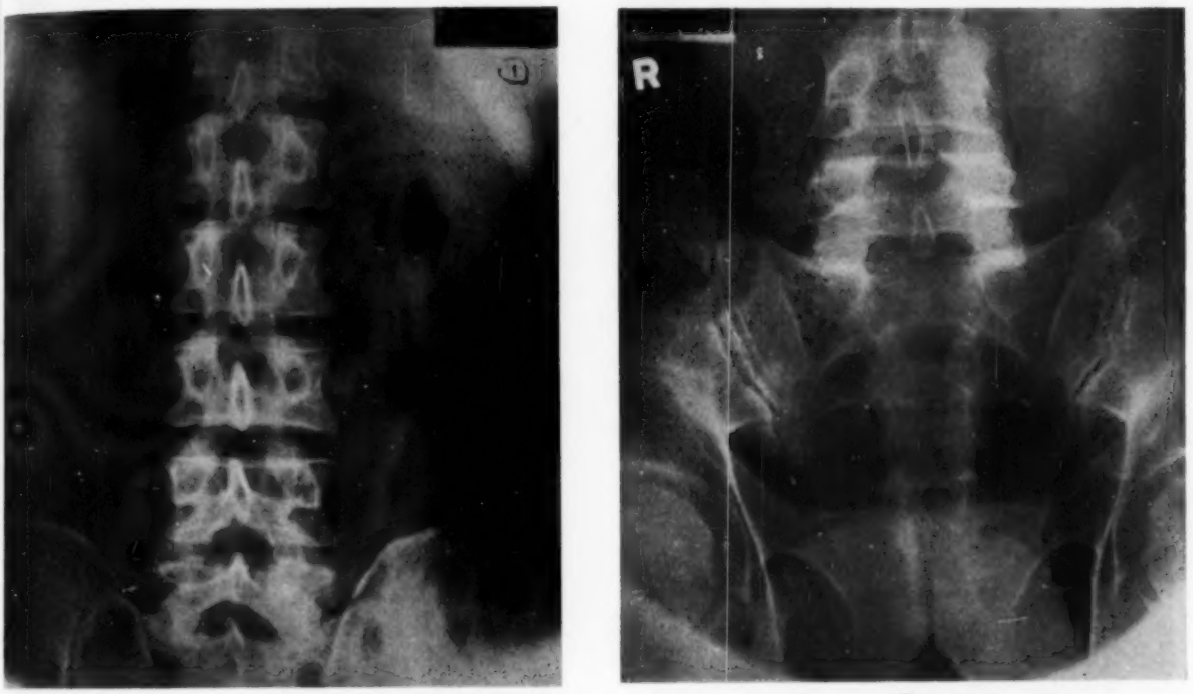
The purpose of this paper is firstly to compare the frequency of both frank and occult sacralization in patients suffering from lumbar intervertebral disk protrusions with that in a control series.

Secondly the neurological findings in the disk series will be analysed, with particular reference to the level of the disk protrusion found at operation.

The radiographs of the lumbar spine of a consecutive series of 150 patients with lumbar disk protrusion, proven by operation, were examined.

*a.* The sacrum showed four pairs of foramina, and five vertebral segments (*Fig.* 358 B).

*b.* The sacrum was set low in the pelvis and the distance from its superior, or articular surface to the intercristal plane above lay between 33 mm. and 56 mm., the average being 41 mm. (*Table I.*)




A B

FIG. 358.—A, Normal lumbosacral spine: lower border of the body of the 4th lumbar vertebra below the intercristal plane; last ribs of medium length. B, Normal sacrum: four pairs of foramina (this tilted view alters the relationship of the lower border of the body of L.4 to the iliac crests).

The control series of radiographs was obtained from intravenous pyelograms of 150 adults. As far as could be ascertained, the age groups were comparable in so far that full growth had occurred and there were no cases of gross spinal disease. The incidence of frank sacralization in both groups was first established. In the straight anteroposterior views the distance from the superior articular surface of the sacrum, or the sacralized lumbar vertebra in cases of sacralization, to the intercristal plane was measured in each case. In addition, the distance between the lower border of the body of the fourth, or penultimate free lumbar vertebra, and the intercristal plane was measured; it was also determined whether the lower surface of the fourth lumbar vertebra was superior or inferior to this plane. Whenever this was possible the length of the last ribs was also recorded, but in a few instances when these ribs were very long they were not always completely included in the radiographs. The sacrum was examined to assess the number of its vertebral components. For this purpose the number of sacral foramina was counted, and the lateral view was of especial assistance.

## RADIOLOGICAL FINDINGS

1. **Non-sacralization.**—The radiological evidence of a normal lumbo sacral spine was determined by the following finding (*Figs.* 358 A, 363):—

*c.* The lower border of the body of the fourth lumbar vertebra (the last-but-one free vertebra) was below the level of the iliac crests. This distance varied between 1 mm. and 22 mm., the average being 9 mm. (*Table II.*)

*Table I.*—AVERAGE DISTANCE FROM THE SUPERIOR SURFACE OF SACRUM, OR SACRALIZED LUMBAR VERTEBRA, TO THE INTERCRISTAL PLANE

| NON-SACRALIZATION | FRANK SACRALIZATION | OCCULT SACRALIZATION |
|---|---|---|
| 41 mm. | 22 mm. | 30 mm. |

*d.* The last ribs were usually short, being under 10 cm. long; in only five instances was their length found to be greater, and in three instances they were rudimentary.

*e.* The fifth lumbar transverse processes were usually of the same dimensions as of those above, but were occasionally greater.

*f.* The spinous process of the fourth lumbar vertebra was level with, or just above, the intercristal plane, in the anteroposterior view.

Non-sacralization was found to occur as follows:

Disk series 45 (30 per cent):

Control series 76 (50·7 per cent). (*Table III.*)

**2. Frank Sacralization.**—This condition was recognized without difficulty. It has been pointed out by Gillespie (1949) that unless a complete count of all the vertebræ has been made it is impossible to

FIG. 359.—Frank sacralization: four free lumbar vertebræ; short last ribs.

decide whether the abnormal vertebra is lumbarized or sacralized. He therefore uses the term 'transitional lumbosacral vertebra'. However, for the sake of clarity 'sacralization' will be employed in this paper. The radiological features were as follows (*Figs.* 359, 365).—

*Table II.*—AVERAGE DISTANCE FROM THE INFERIOR SURFACE OF THE BODY OF THE PENULTIMATE FREE LUMBAR VERTEBRA TO THE INTERCRISTAL PLANE

| ABOVE | BELOW | BELOW |
|---|---|---|
| Non-sacralization | Frank Sacralization | Occult Sacralization |
| 9 mm. | 18 mm. | 9 mm. |

*a.* The transverse processes of the fifth lumbar vertebra were unusually broad and were articulated, or fused with the first sacral alæ inferiorly, the medial aspects of the iliac cresses laterally, or with both.

*b.* The sacrum, together with the abnormal lumbar vertebra, showed six vertebral segments and five pairs of foramina.

*c.* The distance from the superior surface of the body of the sacralized vertebra to the intercristal plane above, varied between 1 mm. and 43 mm., the average distance being 22 mm. (*Table I.*)

*d.* The lower border of the body of the third, or last but one, free lumbar vertebra was well above the intercristal plane, the measurements varying between 13 mm. and 46 mm., the average being 18 mm. (*Table II.*)

*e.* When there were five apparent lumbar vertebræ above that which was sacralized, the last ribs varied between 11 cm. and 16 cm. If only four were seen, the last ribs were either rudementary or very short; in only two cases did they attain the length of 10 cm. These observations indicate that when there are five free lumbar vertebræ sacralization can be overlooked; but long last ribs may indicate its presence, the twelfth thoracic vertebra being almost certainly lumbarized, and the last ribs being absent.

*Table III.*—THE INCIDENCE OF SACRALIZATION

| | NON-SACRALIZATION | FRANK SACRALIZATION | OCCULT SACRALIZATION |
|---|---|---|---|
| Disk series 150 | 45 (30 per cent) | 18 (12 per cent) | 87 (58 per cent) |
| Control series 150 | 76 (50·7 per cent) | 13 (8·7 per cent) | 61 (40·7 per cent) |

FIG. 360.—Hemi-sacralization.

*f.* There was an intervertebral interval between the sacrum and the sacralized lumbar vertebra in 66·6 per cent of these cases, although no disk protrusion had occurred at this level.

Sacralization was found as follows:—

Disk series 18 (12 per cent);
Control series 13 (8·7 per cent). (*Table III.*)

The occurrence of the abnormality in the disk series is not so frequent as that given by Gillespie (1949), who found it to be 16·4 per cent in a series of 500 disk protrusions. He only found it to be 3·2 per cent in a control group. The incidence of sacralization in the control group given above approximates far more closely that of Brailsford (1953), who reported its occurrence as 8·1 per cent in a series of 3000 radiographs of the lumbosacral spine.

*Hemisacralization.*—This variation was found in 5 out of the 18 cases of frank sacralization in the disk series. Although only the transverse process on one side of the abnormal lumbar vertebra was articulated with the ilium, or the sacrum below, the opposite transverse process was always abnormally large (*Fig.* 360). The relationships of the intercristal plane to the lower surface of the body of the third lumbar vertebra above, and to the upper surface of the hemisacralized vertebra below, have been included in the sacralized group. In 3 cases only was it found possible to record the length of the last rib; on each occasion it was longer on the side of the hemisacralization, the average difference being 2 cm.

This abnormality occurred in 3·3 per cent of the disk series and again compared very closely with the incidence of 3·4 per cent given by Brailsford.

**Occult Sacralization.**—When the sacrum was found to be set higher in the pelvis than usual, frank sacralization was not seen, and there were five apparent lumbar vertebræ, a close examination showed that in a number of cases the sacrum was formed by six vertebral segments (*Figs.* 361 B, 364). This is the state of occult sacralization. It was not always possible, however, to determine accurately the number of sacral segments in all the radiographs, but whenever there were six, the sacrum was always found to be highly placed. Notwithstanding the number of sacral segments, occult sacralization was thought to exist where the following further structural anomalies were found (*Figs.* 361 A, 364).

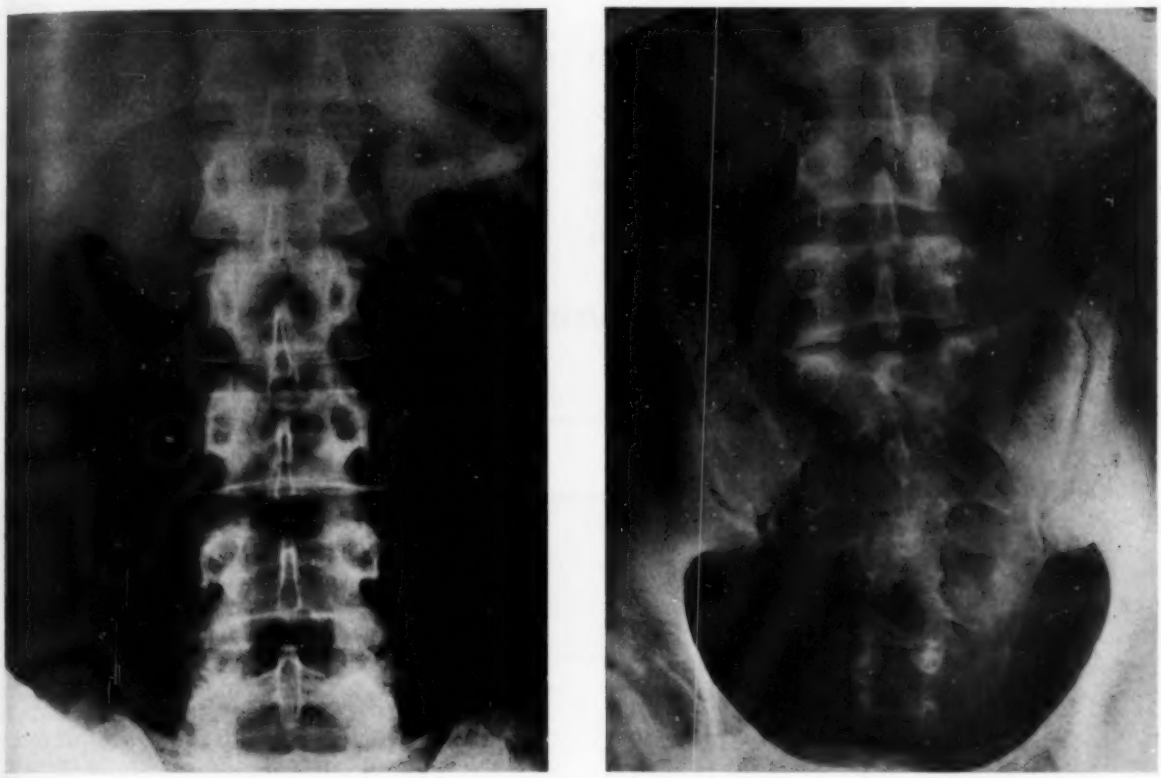
*a.* The sacrum was set too high and the distance from its superior surface to the intercristal plane varied from 22 mm. to 46 mm., the average distance being 30 mm. (*Table I.*)

*b.* The lower surface of the apparent fourth lumbar vertebra was level with, or as high as 22 mm. above, the intercristal plane, the average distance being 9 mm. (*Table II.*)

*c.* The transverse processes of the fifth lumbar vertebra were usually larger than those of the fourth. This variation was also seen in the non-sacralized group, but with much less frequency.

*d.* The spinous process of the fifth lumbar vertebra was either level with, or just below, the iliac crests.

*e.* The last ribs were unusually long. In only 12 instances in the disk series were they less than 10 cm., the shortest being 8 cm. In the remaining 75 cases in this group the last ribs varied from 10 cm. to 17 cm. It was noted that the more highly



A B

FIG. 361.—A, Occult sacralization: lower border of the body of the 4th lumbar vertebra above the intercristal plane; five apparent lumbar vertebræ; last ribs too long to be included in the radiograph; very broad transverse processes of L.5. B, Occult sacralization: the sacrum shows five pairs of sacral foramina.

placed the fourth lumbar vertebra was in relation to the intercristal plane, the greater was the length of the last ribs.

*f*. An additional finding, at operation, was that the spinal canal was wider and deeper at the last interval, in these cases.

Occult sacralization was found to occur as follows :—

Disk series 87 (58 per cent) ;
Control series 61 (40·7 per cent). (*Table III*.)

## THE SIGNIFICANCE OF THE RADIOLOGICAL FINDINGS

The increased incidence of sacralization in patients suffering from verified lumbar intervertebral disk protrusions, in comparison with a control series, has been suggested by the findings given above

surface of the sacrum or the sacralized vertebra to the iliac crests was found to overlap in the three groups of the normal arrangement, frank sacralization, and occult sacralization. These ranges are represented diagrammatically in *Fig*. 362. An explanation for this overlap is that the subjects were not of equal height, and some individuals have much longer vertebral columns than have others. Nevertheless, a study of *Fig*. 362 will indicate that for the majority of cases in each group the distance from the superior surface of the sacrum or sacralized fifth lumbar vertebra, to the iliac crests, is greatest when the normal skeletal arrangement exists, intermediary for occult sacralization, and least for frank sacralization. The average distance for each group is given in *Table I*. and *Fig*. 362 shows that there is no doubt as to their statistical significance.

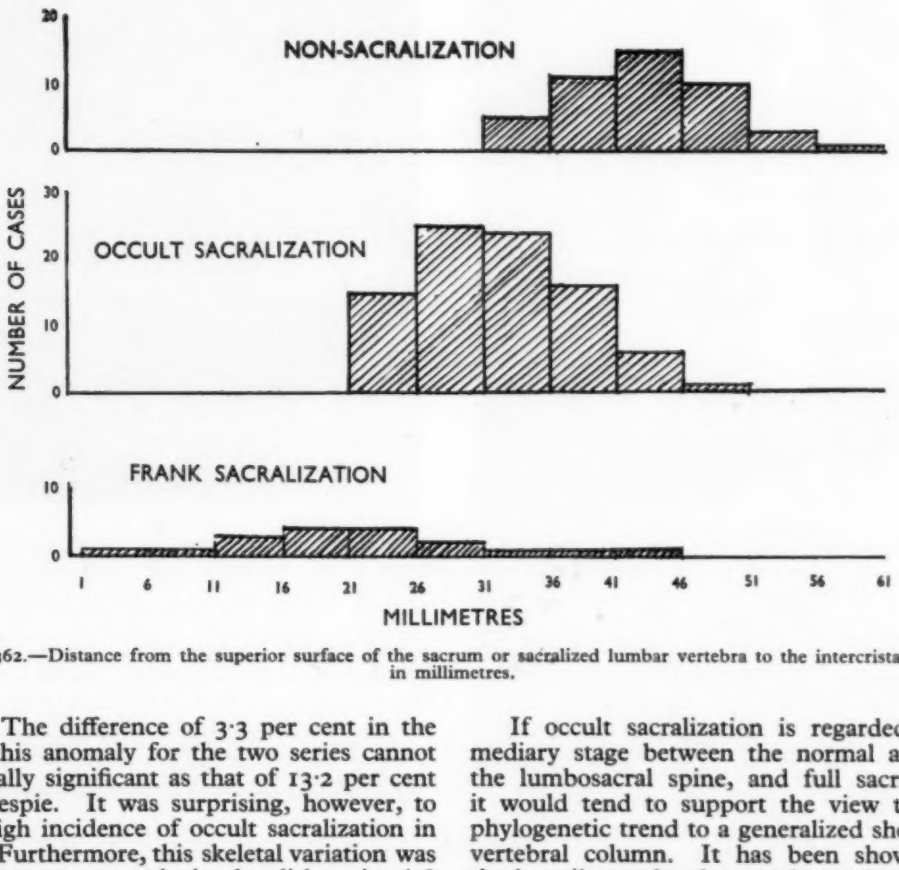



FIG. 362.—Distance from the superior surface of the sacrum or sacralized lumbar vertebra to the intercristal plane in millimetres.

(*Table III*). The difference of 3·3 per cent in the incidence of this anomaly for the two series cannot be so statistically significant as that of 13·2 per cent given by Gillespie. It was surprising, however, to find such a high incidence of occult sacralization in both series. Furthermore, this skeletal variation was found much more commonly in the disk series (58 per cent) than in the control series (40·7 per cent), a difference of 17·3 per cent. A statistical test shows that the difference between these percentages is highly significant ($P < \cdot 01$) and that occult sacralization will be more frequently demonstrated in patients suffering from lumbar intervertebral disk protrusions than in a control series.

The finding that the lower border of the body of the apparent fourth, or last but one, free lumbar vertebra, lay above the intercristal plane, suggested that the sacrum was set too high in the bony pelvis, and furthermore this finding was an easily assessable guide to establishing the presence of occult sacralization. The range of the distances from the superior

If occult sacralization is regarded as an intermediary stage between the normal arrangement of the lumbosacral spine, and full sacralization, then it would tend to support the view that there is a phylogenetic trend to a generalized shortening of the vertebral column. It has been shown above that the last ribs tend to be very long when the sacrum is highly placed even in the absence of frank sacralization. It has not been possible to make a complete count of the whole spinal column, but one might be led to speculate that in the cases of occult sacralization what appears to be the first lumbar vertebra is in reality the twelfth thoracic ; and therefore the last lumbar vertebra must be regarded as the fourth.

If the spinal column is regarded as a flagstaff, and the brim of the false pelvis as the ground level below which it is inserted, the sacrospinalis mass, the quadratus lumborum, and psoas major muscles that surround the lumbar spine may be compared to the stays or guy ropes of the flagstaff. The stability of such a staff will depend not only on its stays, but

also on the ratio between its length above, to its length below the ground. Clearly, a tall pole, fixed only a very short distance into the ground, is less

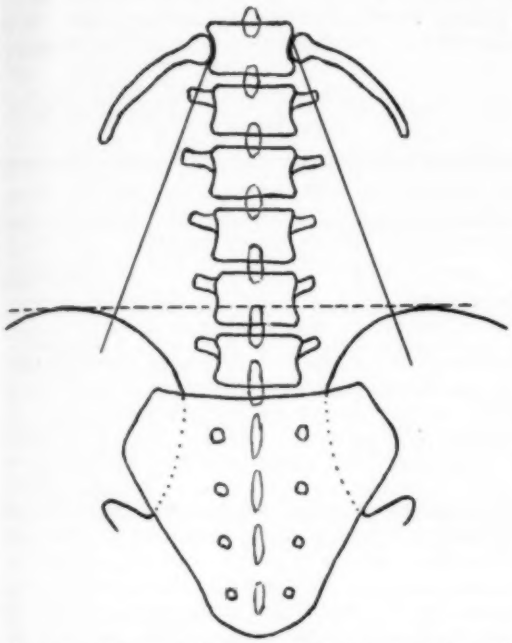


FIG. 363.—Diagram of the normal lumbosacral spine: the most stable arrangement.

secure than one of the same height with a deeper insertion. To continue the simile, the greater the length of the lumbar spine below the intercristal plane, and the greater the distance from the base of the sacrum to this plane, the greater will be the stability of the spine. *Figs.* 363–365 are given to illustrate this point. The finding of a far higher proportion of protusions at the last level as opposed to the penultimate, in the occult sacralization group (*Tables IV–VI*) supports this view; when the normal arrangement existed, protrusions were equally divided between the last two levels. It may be argued that, unlike the vertebral column, a flagstaff is not composed of many articulated components. However, the spine is often held rigid during the types of strain or trauma that predispose to disk protrusions. From the findings given and summarized in *Tables I* and *II* it will be seen that lumbar intervertebral disk protrusions, so often consequent upon trauma, are more likely to occur in the presence of occult and frank sacralization, when the ratio of the length of the spine above the intercristal plane, to that below it, is greater. This hypothesis is supported by the findings in *Table III*.

## THE NEUROLOGICAL FINDINGS IN THE CASES OF INTERVERTEBRAL DISK PROTRUSION

The patient's description of the distribution of pain frequently failed to indicate whether the lumbar 4–5 or the last level was affected. Of greater localizing value however, was the distribution of paræsthesiæ when these existed. The patient was always able to describe accurately their position, so that from the dermatome involved it might be possible to forecast the level of the protrusion. The objective signs considered in the localization of the protrusion were the dermatomes affected by

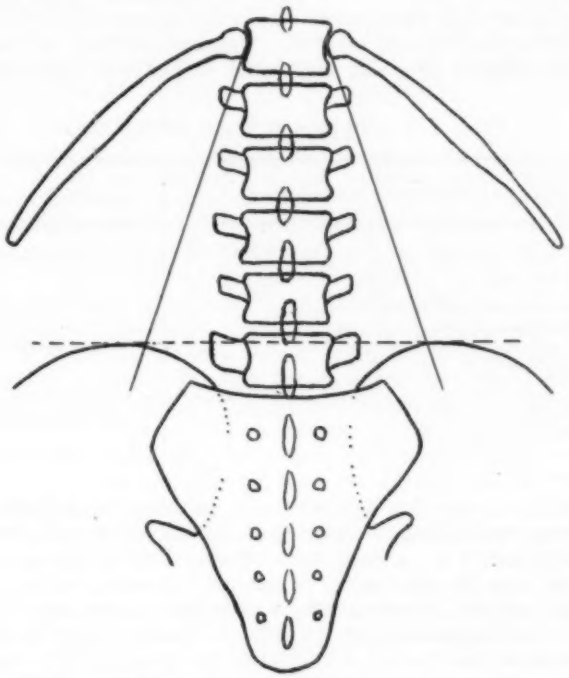


FIG. 364.—Diagram of occult sacralization: structurally less stable.

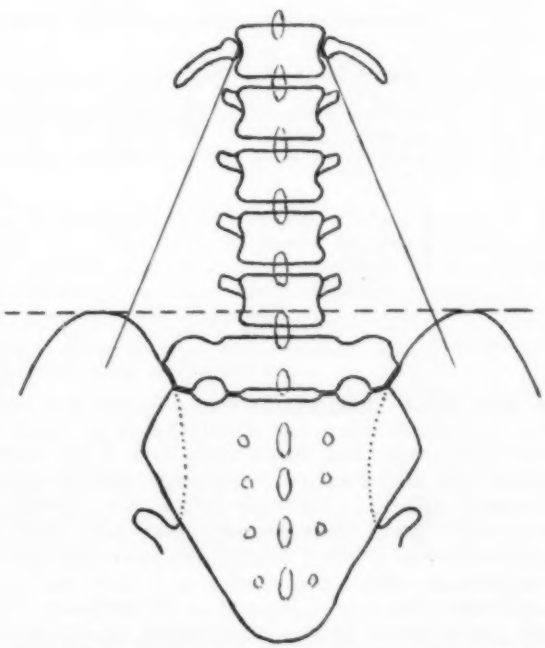


FIG. 365.—Diagram of frank sacralization: structurally the least stable.

sensory impairment, and alterations in the tendon reflexes. Precise mapping out of impairment to sensation is often difficult, especially when the patient has severe pain, but wherever there was a well-marked sensory reduction it was always possible to

find which were the affected dermatomes. It was often found that this loss extended over the distribution of several posterior nerve-roots below the fifth lumbar or first sacral, particularly when there was a large disk protrusion involving intradural as well as the extradural nerves. Because of this finding the highest affected segmental dermatome only has been recorded. Disturbances in knee- and ankle-jerks were always easily assessed and were possibly objectively more accurate. Motor disturbance alone was not thought to be of value in assessing whether the last or the penultimate disk had protruded.

*Table IV.*—Distribution of Paræsthesiæ

| Level of Protrusion | | Absent | L.5 | S.1 | Group |
|---|---|---|---|---|---|
| L.5–S.1 | (22) | 8 | 2 | 12 | Non-sacralization |
| L.4–5 | (20) | 6 | 10 | 4 | |
| L.4–5 and L.5–S.1 | (3) | 1 | 2 | — | |
| L.5–S.1 | (56) | 24 | 19 | 13 | Occult sacralization |
| L.4–5 | (22) | 12 | 8 | 2 | |
| L.5–5 and L.5–S.1 | (9) | 2 | 5 | 2 | |
| L.4–5 | (17) | 7 | 8 | 2 | Frank sacralization |
| L.3–4 | (1) | 1 | | | |

**1. Paræsthesiæ** (*Table IV*).—In most cases paræsthesiæ were noted by the patient. It was found that with last intervertebral disk protrusions the first sacral dermatome was affected six times more frequently than the fifth lumbar in cases of non-sacralization, but when there was occult sacralization the fifth lumbar dermatome was the more frequently affected, the ratio being 19 : 13. When there was frank sacralization the fifth lumbar dermatome was affected four times more frequently. Discrepancies when the lumbar 4–5 disk had protruded were less common, and in no instances were there paræsthesiæ in the distribution of the fourth lumbar nerve-root. On the one occasion when the last but one or true lumbar 3–4 disk (in a case of full sacralization) had herniated, there were no paræsthesiæ.

**2. Sensory Impairment** (*Table V*).—Just as paræsthesiæ were more frequently present than absent, so also were sensory disturbances. It was found that the highest segmental level involved was the fifth lumbar dermatome in 7 patients out of 22 who had disk protrusions at the last interval, and whose spines showed non-sacralization. The first sacral dermatome was the highest affected in 5 of this group, whereas 10 had no sensory loss. It will be seen in *Table V*, however, that in the presence of occult sacralization, when the last disk had protruded, the fifth lumbar dermatome was twice more frequently affected than the first sacral. In all instances of frank sacralization the sensory loss, when found, extended up to the field innervated by the fifth lumbar root, and there were similar findings when the lumbar 4–5 interval was abnormal in the groups of both non- and occult sacralization. Sensory loss extended up to involve the fourth lumbar nerve-root territory in only 2 instances, and on each occasion the affected disk was the apparent lumbar 4–5 and there was occult sacralization.

*Table V.*—Upper Segmental Limit of Sensory Impairment

| Level of Protrusion | | No Loss | S.1 | L.5 | L.4 | Group |
|---|---|---|---|---|---|---|
| L.5–S.1 | (22) | 10 | 5 | 7 | — | Non-sacralization |
| L.4–5 | (20) | 6 | 3 | 11 | — | |
| L.5–S.1 and L.4–5 | (3) | 1 | — | 2 | — | |
| L.5–S.1 | (56) | 20 | 12 | 24 | — | Occult sacralization |
| L.4–5 | (22) | 3 | 3 | 14 | 2 | |
| L.5–S.1 and L.4–5 | (9) | 1 | 2 | 6 | — | |
| L.4–5 | (17) | 5 | — | 12 | — | Frank sacralization |
| L.3–4 | (1) | 1 | — | | — | |

*Table VI.*—Reflex Disturbances

| Level of Protrusion | | Ankle-jerk | | | Knee-jerk | Group |
|---|---|---|---|---|---|---|
| | | Normal | Reduced | Absent | Also reduced | |
| L.5–S.1 | (22) | 4 | 9 | 9 | — | Non-sacralization |
| L.4–5 | (20) | 10 | 5 | 5 | 2 | |
| L.4–5 and L.5–S.1 | (3) | — | 2 | 1 | 1 | |
| L.5–S.1 | (56) | 16 | 26 | 14 | 4 | Occult sacralization |
| L.4–5 | (22) | 9 | 11 | 2 | 1 | |
| L.4–5 and L.5–S.1 | (9) | 1 | 6 | 2 | — | |
| L.4–5 | (17) | 5 | 8 | 4 | — | Frank sacralization |
| L.3–4 | (1) | 1 | — | — | — | |

**3. Reflex Disturbance** (*Table VI*).—The finding of a reduced or absent ankle-jerk in these cases may indicate an injury to the afferent or efferent sides of the reflex arc. Whereas 31·3 per cent of all cases were free from sensory loss, and only a very small number showed weakness at the ankle-joint, only 18·2 per cent of patients with lumbosacral disk protrusions but with no evidence of occult or frank sacralization had normal ankle-jerks. It would therefore seem that as tendon-reflexes are dependent on two peripheral pathways, impairment of the ankle-jerk might be the most frequent abnormal neurological finding. For this reason a large lumbar 4–5 disk protrusion, which begins to encroach upon the cauda

equina, may often be associated with a diminished or absent ankle-jerk.

It was found, however, that when the disk protrusions occurred at the last interval, the ankle-jerk was normal in 18·2 per cent of the non-sacralized group, and in 28·6 per cent of the occult sacralization group. The reflex was completely absent in 40·9 per cent of the former group and in only 25·0 per cent of the latter group. As might be expected, the ankle-jerk was conserved or only diminished in a greater proportion of lumbar 4–5 protrusions of both groups, and in protrusions at the last intervals in the group of frank sacralization. The knee-jerk was reduced so infrequently as to be of no statistical significance.

## DISCUSSION OF THE NEUROLOGICAL FINDINGS

In patients who were operated on for disabling sciatica, it was found that the extrathecal nerve was either stretched over, compressed by, or partially fixed by adhesions to the underlying disk protrusion. On anatomical grounds, when the lumbosacral disk has protruded the first sacral root would be expected to be affected. Thus sensory impairment and paræsthesiæ would be present in the lateral border and sole of the foot; and the Achilles reflex (S.1–2) diminished or absent. When the disk above is abnormal the fifth lumbar root should give evidence of impaired conductivity and the area showing hypæsthesia and paræsthesia should be on the dorsum of the foot. The ankle-jerk should be normal, or reduced only in the presence of a large disk protrusion encroaching upon the cauda equina.

A study of *Tables IV* to *VI* will show that the greatest number of discrepancies in the neurological findings are found when the protrusions occur at the last interval. When there is frank sacralization it is clear that a disk lesion at the last, or true lumbar 4–5 interval, will interfere with the function of the fifth lumbar root, and the neurological findings in these cases bear this out. In the absence of either form of sacralization, a last-interval disk protrusion usually gives evidence of a lesion of the first sacral root. It is in the group of occult sacralization that the neurological findings are at greater variance, the nerve-root affected being one higher than that anticipated. If it is true that this condition represents an intermediary stage between full sacralization and the normal skeletal arrangement, and when the sacrum is very highly placed, it is possible that the last lumbar vertebra may in fact be the fourth. Such a hypothesis may explain why the fifth lumbar root is affected in an appreciably greater proportion than the first sacral root, when disk lesions occur at the last interval in this group. It has been indicated above that the relationship of the lower border of the body of the fourth lumbar vertebra to the intercristal plane was an arbitrary level to serve as an easily assessable guide to the presence of this transitional state. Therefore, in cases where the anomaly is not so marked, it may be less likely that the fifth lumbar, and not the first sacral root, will be affected by a disk protrusion at the last interval.

## SUMMARY

1. An intermediary stage between the normal skeletal arrangement of the lumbosacral spine and full sacralization has been described. This variation —namely, 'occult sacralization'—is characterized by a highly placed sacrum in relation to the inlet of the false pelvis, and the presence of six sacral vertebral segments. The transverse processes of the fifth lumbar vertebra are usually larger than those above, and the last ribs are abnormally long. The spine of the fifth lumbar vertebra may be level with, or just below, the iliac crests. The condition is relatively common.

2. It has been found that both frank and occult sacralization occur more frequently in patients suffering from lumbar intervertebral disk lesions than in a control series of lumbar spines. A hypothesis is suggested whereby these variations structurally weaken the stability of the vertebral column and predispose to lumbar intervertebral disk protrusions.

3. Where either anomaly is found in patients suffering from intervertebral disk protrusions, the neurological symptoms and signs are more frequently at variance with those expected from the level of the protrusion. The cause for this is obvious in frank sacralization; in the cases of occult sacralization it would appear that the explanation may be that the last lumbar vertebra is in reality the fourth, and therefore a disk protrusion at the last intervertebral space will interfere with the function of the fifth lumbar, and not the first sacral root.

The author wishes to express his thanks to Mr. J. E. A. O'Connell, at whose suggestion this work was carried out, and for his constant encouragement and advice; to Mr. M. P. Curwen, statistician to St. Bartholomew's Hospital, for his helpful advice; and to Mr. N. K. Harrison for the photographic reproductions and diagrams.

## REFERENCES

BRAILSFORD, J. F. (1953), *The Radiology of Bones and Joints*. London: Churchill.

GILLESPIE, H. W. (1949), *Brit. J. Radiol.*, **22**, 270.

O'CONNELL, J. E. A. (1951), *J. Bone Jt Surg.*, **33 B**, 8.

# ACRYLIC CRANIOPLASTY

## A SIMPLE ONE-STAGE METHOD USING A COLD CURING MATERIAL

By R. G. ROBINSON, G.M., AND A. D. MACALISTER

DEPARTMENT OF NEUROSURGERY, DUNEDIN HOSPITAL, DUNEDIN, AND UNIVERSITY OF OTAGO DENTAL SCHOOL, N.Z.

THERE are two main ways of repairing skull defects. One method involves using bone, either autogenous or heterogenous, and the other is to use a metal or synthetic material. The end-result of either method is satisfactory. Alloplastic materials have the advantage that they do not need another operation to obtain the repairing material. The most popular metal for skull defects has been tantalum.

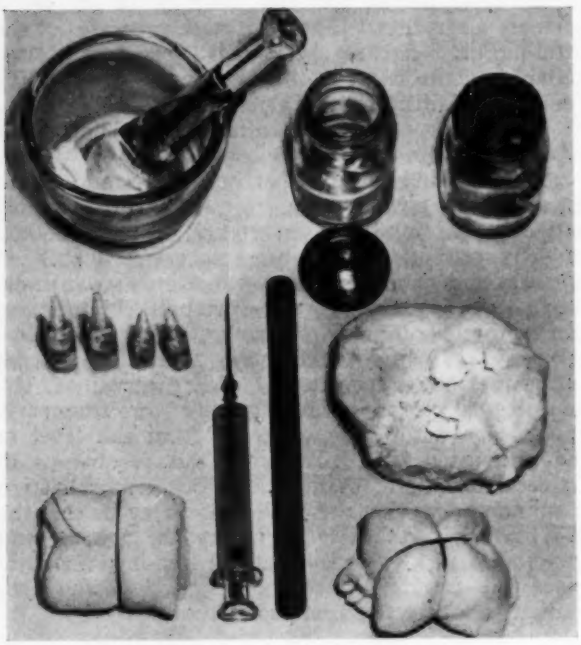


FIG. 366.—The mixing set-up, showing the monomer in sealed ampoules, the autoclaved packets of the polymer, the mortar, and lidded jars.

A substance known as methyl methacrylate was produced commercially in 1927. This material has several chemical forms. There is a liquid or monomer and a powder or polymer. The two can be combined under the action of heat and pressure to form a solid translucent substance known as acrylic resin. This process is known as polymerization. This plastic material is used extensively in dentistry.

During the Second World War acrylic resin was used for cranioplasty. Kahn (1943) and Kerr (1943) used preformed acrylic plates for skull defects. Later Beck, Russell, Small, and Graham (1945) showed that the material gave rise to a trivial tissue reaction when implanted into the skull of rabbits. Small and Graham (1945) did acrylic cranioplasties in two operations. At the first, a direct impression of the skull defect was taken, the laboratory work was done, and the plate inserted at the second operation. Elkins and Cameron (1946) speeded up the laboratory work and did the repair in one long session. Thus the method of acrylic cranioplasty was cumbersome and needed ancillary facilities.

Blaine (1945) noted that a mixture of the polymer and monomer would harden in 24 hours when implanted in the body. Blaine and Oliver (1951) did a successful series of human cranioplasties by this means. We were exploring this idea when we found that an acrylic resin was available locally that would harden in under half an hour by simple mixing. This was Simplex Pentocryl, a cold-curing acrylic resin made by Dental Fillings Ltd., London. We used the pink shade throughout. While our work was in progress the paper by Woringer, Schweig, Brogly, and Schneider (1951) became available. Recently Dodge and Craig (1953) have used the method.

### MATERIALS

The Simplex Pentocryl consists of two substances. The liquid monomer is a volatile fluid with a B.P. of 100·3° C. The polymer is a fine-grain powder that softens at 80° C. The two substances, when mixed in suitable proportions, polymerize to a hard mass in a short time at room temperature and without the application of external heat. This rapid action is due to chemical accelerators, of which benzoyl peroxide and dimethyl toluidene are the best known. The resin has a Knoop hardness number of 14·2 at 15° C. after 24 hours. Microscopical examination shows that the mass has a porous matrix. The diameter of the pores is about 14$\mu$.

This acrylic resin has been implanted into the skull of animals and found to excite a minimal tissue reaction comparable to that of tantalum (Woringer and others, 1951; Dodge and Craig, 1953).

### STERILIZATION

The polymer was sterilized by wrapping small quantities in gauze packets and autoclaving at 120° C. for 15 minutes. The grains became loosely fused and the lumps were ground down in a pharmacist's mortar (*Fig.* 366). Tests showed that there was no alteration in its basic properties. It must be emphasized that the powder must be ground down finely for proper results.

Some of the monomer was distilled, but when mixed with the polymer did not harden as rapidly as the natural product. Blaine and Oliver (1951) made no mention of the sterility of the liquid. Woringer and others (1951) reported that the monomer was bacteriostatic and self-sterilizing after storage. At our request Messrs. F. J. Bergensen and D. F. Bacon, of the Department of Bacteriology, University of Otago, carried out a series of experiments with the monomer.

They found that this liquid was difficult to work with as it did not mix with either water or the common bacteriological media. To overcome this difficulty,

sterile strips of filter-paper were soaked in suspensions of active cultures of *Staph. aureus*, *Esch. coli*, and *Cl. welchii*. The strips were dried at 37° C. in sterile petri dishes and then were put in corked tubes of the monomer that had been sterilized by passage through a Seitz filter. At intervals the strips were removed from the tubes, the monomer evaporated, and then they were dropped into tubes of Robertson's cooked meat broth. After incubation at 37° C. for 24 hours the tubes were examined for organisms. *Table I* gives these results, and it can be seen that only *Cl. welchii* was inhibited by the monomer after 2 hours' exposure.

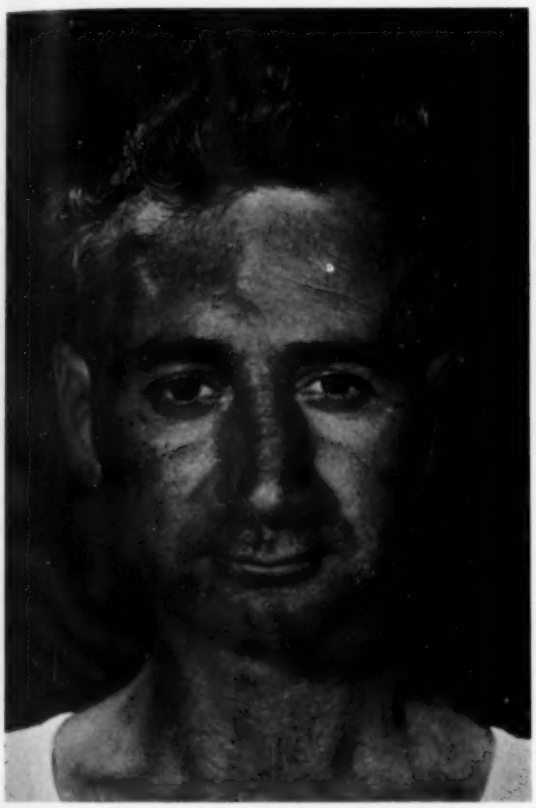


FIG. 367.—Right frontal bone defect due to gunshot wound before cranioplasty.

FIG. 368.—Same case as in *Fig.* 367 after cranioplasty, showing the coronal incision.

*Table I.*—ANALYSIS OF RESULTS OF BACTERIA INCUBATED WITH THE ACRYLIC MONOMER

| *Period of Contact with the Monomer* | *Staph. aureus* | *Esch. coli* | *Cl. welchii* |
|---|---|---|---|
| Control | growth | growth | growth |
| 5 minutes | " | " | " |
| 45 minutes | " | " | " |
| 2 hours | " | " | No growth |
| 8 hours | " | " | " " |
| 24 hours | " | " | " " |
| 48 hours | " | " | " " |

*Staph. aureus*, β-streptococci, *Esch. coli*, and *Cl. welchii* were inoculated into broth to which 10 per cent of the monomer had been added. The cultures were examined after 48 hours. It was found that *Esch. coli* and *Cl. welchii* had failed to grow and that *Staph. aureus* and β-streptococci grew freely in the presence of the monomer.

Pieces of acrylic resin were made up by using monomer that had been mixed with *Staph. aureus* and *Cl. welchii* half an hour before. The pieces were inserted subcutaneously into 6 rabbits (R. G. R.). The animals were killed after fourteen days. From all animals the organisms were recovered and there were signs of local infection. The acrylic resin and its adjacent staphylococcal abscess were sectioned. The outer part of the porous matrix of the resin had been invaded by polymorphs and fibroblasts. Clumps of staphylococci were seen in the pores.

These experiments showed that the self-sterilizing powers of the monomer were limited. An adequate degree of sterility was ensured, therefore, by passing the liquid through bacterial filters and sealing it into 2 c.c. and 5 c.c. sterile ampoules.

## PREPARATION

The autoclaved powder is ground in a sterile pharmacist's mortar and placed in a sterile jar with a lid. The necessary amount of the liquid is withdrawn by a syringe from ampoules (*Fig.* 366). The liquid is gradually added to the powder and the whole stirred vigorously, being careful to incorporate all the powder in the liquid. At first the mixture has the consistency of damp sand, then it becomes tacky and will adhere to instruments or gloves. The

next stage is that of a dough, which has the same consistency as dough used in cookery. The dough does not stick to gloves and instruments. It is advisable to let the ' doughing ' occur in a closed jar.

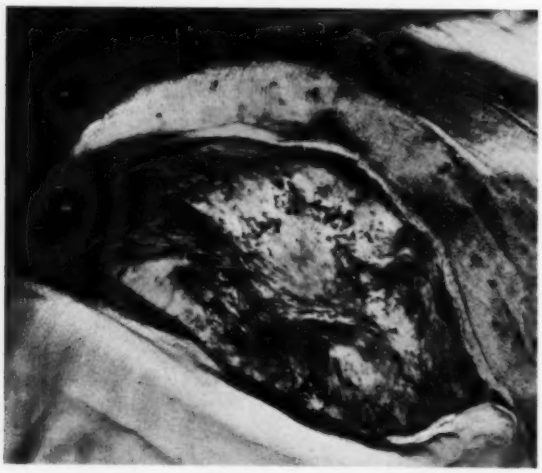


FIG. 369.– Same case. The area of the defect after scalp reflection.

FIG. 370.— Same case. The area of the bone defect after preparation and ready for cranioplasty.

Excessive evaporation of the liquid leads to a ' false ' polymerization, and the final material is deficient in strength. At theatre temperature, the dough stage is reached within 5 minutes. Too much monomer will give a sloppy mix, but this does not alter the end-product but merely lengthens the ' doughing ' stage.

Once the dough stage has been reached, the material must be moulded into place and trimmed within ten minutes. After that time it is too rubbery for manipulation and is soon hard. Any rise in temperature will increase the rate of setting.

The proportion of the powder to the liquid is about 3 to 1 by volume. It was found that 25 c.c. by volume of the powder when mixed with 8 c.c. of the liquid would occupy a space 6 × 5 × 0·5 cm when it had set. In our method the dough is made oversize, so these quantities would be suitable for about 5 per cent less than the above volume.

## METHOD

Most of these acrylic cranioplasties were done using induced hypotension with hexamethonium bromide and negative pressure (James, Coulter, and Saunders, 1953). This lessens the oozing that can occur when an old wound is opened. There was no evidence of any excessive collections of fluid under the skin-flaps in the post-operative period.

In most cases the previous skin wound was used and the scar excised. For frontal defects a coronal skin-flap was raised as suggested by Blaine and Oliver (1951) (*Figs.* 367, 368). The edges of the bone defect are cleared of tissue. The dura mater is separated from the bone edge for ¼ in. (*Figs.* 369, 370). It is an advantage to dissect up a hinged soft-tissue flap from the area of the skull defect. The hæmostasis is revised and the defect is ready for filling in. The mixing of the dough is described above. The dough is pressed into the skull defect and the excess is cut away ½ in. over size. The mass is heaped up

FIG. 371.— Same case. The bone defect filled with acrylic resin. Note the two drainage holes.

to the centre so that it has a thin periphery. The thin margin is worked under the bone edge with a periosteal elevator. This will form a retaining lip when the dough hardens. The dough is moulded into the rest of the defect. Any excess is trimmed off with scissors. Scissors are better than a knife, as the material drags along the knife edge. Drainage holes can be made by boring through with a hæmostat (*Fig.* 371). The prosthesis must be completed in ten minutes. The polymerization can be hastened by irrigation with Ringer's solution at 105° F. The tissue flap is sewn to the surrounding pericranium. The skin incision is closed in two layers and no drain is used. No special type of head dressing is necessary. The patient does not lie on the cranioplasty until the

next day and a notice to this effect is stuck to the covering bandage. A short course of penicillin is given post-operatively.

With a large skull defect this dough may set before proper moulding has been done. The largest defect was 100 sq. cm. This was filled in with two pieces, inserted consecutively. No difficulty was found in dovetailing the sections together.

The patient can be discharged from hospital at the end of a week. He is advised that he should take care of his head for three months. The only permanent restrictions that have been suggested to the patients are not to box or play rugby and association football.

## RESULTS

Fourteen of these acrylic cranioplasties have been done. Thirteen had skull defects due to old head injuries and one was due to removal of an infected bone-flap. The size of the defects varied between 10 and 100 sq. cm. The least interval between head injury and cranioplasty was two months, and in none was there any infection following the primary wound toilet. These 13 cases have all made uneventful recoveries following cranioplasty and no plates have been removed. The longest follow-up has been two years and all patients have expressed themselves satisfied with the immediate result.

The interval between the removal of the infected bone-flap and cranioplasty was seven months. The plate was removed after six months because of recrudescence of the infection. It is possible that a longer interval between the operations might have led to a more favourable outcome.

## DISCUSSION

The main difference between our method and that of Woringer and others (1951) is over the sterilization of the basic materials. They sterilized neither the liquid nor the powder and had no infection in 15 cases. They considered that the monomer was bacteriostatic but did not make it entirely clear whether it was bacteriocidal. Our investigations show that the monomer has a trivial bacteriocidal effect and it was not bacteriostatic to *Staph. aureus* and β-streptococci. Further, acrylic plates made with bacterially contaminated monomer showed wound infections after fourteen days in rabbits. These results left us with no option but to sterilize the monomer, and this was done by a bacterial filter. Autoclaving sterilizes the powder. Some of the differences between our results and those of Woringer and others (1951) lie in the difficulties of handling the monomer. Dodge and Craig (1953) found the finished product to be sterile. This does not satisfy us as the acrylic plate has a spongy matrix in which bacteria may become locked away and give harmful effect later. We have insisted on sterility at all stages in making an acrylic plate.

This method of cranioplasty has the advantage over other alloplastic methods in that any intricate defect can be filled with ease. Size is a limiting factor and this can be overcome by fitting several pieces together. The retentive lip means that no other method of fixation is needed. We would not recommend using this method directly on the brain as we have no information as to any possible adverse effects. All our cases had an intact dura mater.

The acrylic plate is translucent to X-rays. The materials are easily obtained and are inexpensive. All the indications are that this cold-curing acrylic resin is a satisfactory substance for an alloplastic cranioplasty.

## SUMMARY

The use of a cold-curing acrylic resin for cranioplasties is described. Investigations were carried out on ways of sterilizing the primary materials. The powder was autoclaved. The liquid was found to inhibit the growth of some bacteria and was sterilized by filtration. The method of using the materials is described. Fourteen cranioplasties have been done with good results, but one plate was removed later. The bacteriological investigations have been discussed. The method is considered satisfactory.

We are especially grateful to Mr. F. J. Bergersen, B.Sc., and Mr. D. F. Bacon, B.Sc., for their bacteriological investigations. We are indebted to Dr. M. J. Marples for bacteriological advice and to Professor E. F. D'Ath for bacterial filtration of the monomer. Mr. A. James was kind enough to refer many of these cases for cranioplasty.

## REFERENCES

BECK, D. J. K., RUSSELL, D. S., SMALL, J. M., and GRAHAM, M. P. (1945), *Brit. J. Surg.*, **33**, 83.
BLAINE, G. (1945), *Ibid.*, **33**, 245.
— — and OLIVER, L. C. (1951), *Ibid.*, **39**, 371.
DODGE, H. W., and CRAIG, W. McK. (1953), *Proc. Mayo Clin.*, **28**, 256.
ELKINS, C. W., and CAMERON, J. E. (1946), *J. Neurosurg.*, **3**, 199.
JAMES, A., COULTER, R. L., and SAUNDERS, J. W. (1953), *Lancet*, **1**, 412.
KAHN, E. A. (1943), *J. Neurol. Psychiat.*, **6**, 158.
KERR, A. S. (1943), *Ibid.*, **6**, 158.
SMALL, J. M., and GRAHAM, M. P. (1945), *Brit. J. Surg.*, **33**, 106.
WORINGER, E., SCHWEIG, B., BROGLY, G., and SCHNEIDER, J. (1951), *Rev. neurol.*, **85**, 527.

# EXPERIMENTAL SURGERY

## SOME PHYSICAL PROPERTIES OF VASCULAR GRAFTS

### WITH PARTICULAR REFERENCE TO THE SUTURE-HOLDING POWER AFTER PRESERVATION

By R. WARWICK-BROWN

SURGICAL PROFESSORIAL UNIT, ST. BARTHOLOMEW'S HOSPITAL, LONDON

In recent years there has been a great increase in the clinical and experimental use of grafts in the surgical treatment of vascular diseases. Many methods for the preservation of the graft material have been tried and so a study has been made of the effect of various agents on the physical properties of grafts, particularly with regard to their suture-holding power.

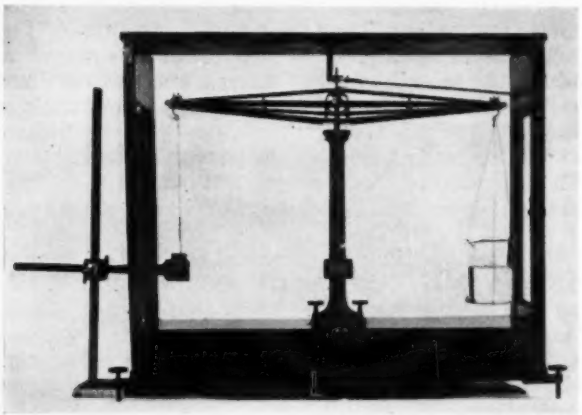


FIG. 372.—Apparatus used to determine the suture-holding power of a graft. (For description, *see* text.)

The methods of preservation in common use can be divided into two main groups. First there are the physical methods which use intense cold, either by deep freezing, the method used by Eastcott and Hufnagel (1950) for homografts in man, or by the freeze-drying process, introduced by Hufnagel (1953) for homografts in man and animals. This group necessitates an aseptic method for the preparation of the transplants because the cold does not sterilize them. This may present difficulties.

Secondly there are the chemical methods, using sterilizing fluids. Formalin or formol-saline has been used by Levin and Larkin (1907) for aortic homografts in dogs, by Guthrie (1910) for homografts and heterografts in animals, and by Pierce, Rheinlander, Moritz, Gross, and Merrill (1949) for homografts also in dogs. Ethyl alcohol (75 per cent) has been used successfully for aortic homografts in man by Nakayama (1953). A third agent, ethylene oxide, has been introduced into the field recently by Hufnagel, Rabil, and Reed, (1953) to sterilize vessels prior to homografting. These fluids possess the advantage that they can be used to sterilize as well as preserve the grafts thus avoiding the necessity of obtaining them by aseptic means.

## MATERIALS AND METHODS

This investigation was carried out using the aorta and inferior vena cava from rabbits, as this material was most readily available. The vessels were removed from freshly killed rabbits, washed in water, and then threaded on to lengths of glass rod of suitable diameter in order to preserve the lumen, before being subjected to the various methods of preservation.

A small control group of vessels, Group 1, was tested in the fresh state or after being kept for short periods in Ringer-Locke solution. The remainder were divided into groups for preservation as follows:

Group 2. Deep freeze.
Group 3. Freeze-dried.
Group 4. 4 per cent formol-saline.
Group 5. 75 per cent ethyl alcohol.
Group 6. Ethylene oxide (liquid).
Group 7. Ethylene oxide (after initial period in 4 per cent formol-saline).

In order to eliminate to some extent the variations in the intrinsic strength of the vessels from different rabbits, some of the vessels were divided into portions which were placed in different preservation groups for subsequent comparison. The effects of different periods of preservation were also investigated. In many cases the same vessel was retested after further preservation.

The mechanical strength of each graft was assessed by measuring its suture-holding power by the following method (*Fig.* 372): Each vessel was transected at right-angles to its length and a piece of 4/0 braided silk ('Mersilk') on a 14-mm. Vogt's corneal needle was passed through the vessel wall approximately 1 mm. from the cut edge. The vessel was then fixed between pieces of cork in the clamp of a heavy retort stand, which was arranged below one arm of a chemical balance. The silk, tied to form a loop, was attached to a hook on the balance arm, the stand being adjusted until the silk was vertical and just taut. On the other side of the balance was placed a weighed beaker, and water was run into the beaker until the silk cut free from the vessel wall. The mass of the water added at this point together with the mass of the beaker was taken to be a measure of the suture-holding power of the vessel concerned. This process was performed ten times on each vessel, a fresh transverse cut being made before passing the suture, and a mean value was deduced in order to eliminate as far as possible errors in the experimental method. One source of error was the slight variation in the thickness of the vessel wall at the origin of branches, and, when seen, these sites were

avoided. Another was the exact placing of the suture, the distance of 1 mm. from the cut edge being judged by eye, but as the same method is used in grafting operations this was not felt to detract from the observations provided that a mean value was taken. The vessels were kept moist throughout the test period in order better to simulate operative conditions.

*Table I.*—EXPERIMENTAL RESULTS

| PRESERVING AGENT | SERIAL NO. OF GRAFT | PERIOD OF PRESERVATION | BREAKING STRAIN IN GRAMS (MEAN OF 10 OBSERVATIONS) | | | |
|---|---|---|---|---|---|---|
| | | | Aorta | Group Mean | Inferior vena cava | Group Mean |
| 1. Ringer-Locke | 7 | 1 d. | 77 | | — | |
| | 8 | 1 d. | 61 | | — | |
| | 19 | 1 d. | 105 | | 231 | |
| | 19 | 8 d. | 114 | | 178 | |
| | 20 | fresh | 100 | | 132 | |
| | 20 | 7 d. | 108 | 94 | 296 | 209 |
| 2. Deep freeze | 9 | 1 d. | 113 | | — | |
| | 9 | 7 d. | 160 | | — | |
| | 12 | 1 d. | 138 | | — | |
| | 17 | 3 d. | 130 | 135 | 188 | 188 |
| 3. Freeze-dried | 18 | — | 107 | 107 | 191 | 191 |
| 4. Formol-saline, 4 per cent | 2 | 37 d. | 67 | | 200 | |
| | 2 | 55 d. | 59 | | — | |
| | 2 | 79 d. | — | | 190 | |
| | 3 | 18 d. | 101 | | 90 | |
| | 3 | 32 d. | 117 | | — | |
| | 3 | 59 d. | — | | 94 | |
| | 4 | 5 d. | 72 | | 106 | |
| | 4 | 15 d. | 77 | | — | |
| | 4 | 43 d. | — | | 102 | |
| | 5 | 4 d. | 72 | | — | |
| | 5 | 19 d. | 81 | | — | |
| | 6 | 12 d. | 94 | | 126 | |
| | 6 | 22 d. | 97 | | 160 | |
| | 6 | 42 d. | — | | 126 | |
| | 7 | 37 d. | — | | 277 | |
| | 7 | 38 d. | 156 | | — | |
| | 8 | 39 d. | 162 | 96 | — | 147 |
| 5. Ethyl alcohol, 75 per cent | 1 | 50 d. | 220 | | — | |
| | 1 | 67 d. | 201 | | — | |
| | 13 | 1 d. | 160 | | — | |
| | 15 | 3 d. | 237 | 205 | 151 | 151 |
| 6. Ethylene oxide | 10 | 1 d. | 220 | | 126 | |
| | 10 | 7 d. | 169 | | — | |
| | 10 | 22 d. | — | | 144 | |
| | 11 | ½ h. | 224 | | — | |
| | 11 | 1 d. | 249 | | — | |
| | 14 | 1 d. | 192 | | — | |
| | 16 | 3 d. | 181 | 206 | 148 | 139 |
| 7. Ethylene oxide (after initial period in 4 percent formol-saline) | 3 | 63 d., 3 hr. | — | | 136 | |
| | 4 | 30 d., ½ hr. | 210 | | — | |
| | 4 | 47 d., 4 hr. | — | | 97 | |
| | 5 | 34 d., ½ hr. | 186 | | — | |
| | 6 | 34 d., ½ hr. | 239 | | — | |
| | 7 | 38 d., ½ hr. | 240 | | 267 | |
| | 8 | 38 d., 1 hr. | 310 | 237 | 196 | 174 |

## RESULTS

The results of the experiments are shown in full in *Table I*, where the mean values obtained for each vessel are indicated. *Table II* gives a summary of the mean values obtained in each preservation group, and for ease of comparison the percentage changes produced by the different methods are shown.

## CONCLUSIONS

From the results obtained it would appear that the method of preservation of vascular grafts exerts a considerable effect on their suture-holding power. In the vessels examined, the rabbit aorta and inferior vena cava, the effect of the preservation method on the aorta appeared to be more than in the case of the vena cava. In the fresh state the vena cava was approximately twice as strong as the aorta despite the extreme thinness of the former's wall. When preserved, however, the vena cava was somewhat weaker, whereas the preserved aorta generally showed an increased suture-holding power. The physical methods, deep freezing and freeze drying, exerted a small effect only on both vessels, the artery being slightly strengthened by freeze-drying (+ 14 per cent) and more so by deep freezing (+ 44 per cent), and the vein being slightly weakened (− 9 per cent and − 10 per cent) by each method respectively. Among the chemical methods, formol-saline produced almost no change in the artery (+ 2 per cent), but a considerable reduction in the strength of the vein (− 30 per cent), while ethyl alcohol and ethylene oxide rather more than doubled the strength of the aorta (+ 118 per cent and + 116 per cent respectively), but

reduced that of the vena cava (− 28 per cent and − 33 per cent). In Group 7, where formol-saline preserved vessels were placed for short periods in ethylene oxide, the aorta was strengthened by 152 per cent whereas the vena cava was weakened by 17 per cent. The period of preservation had little effect on the degree of change produced by the various agents.

As a result of these observations it was concluded that, on the grounds of suture-holding power alone, aortic grafts preserved by ethyl alcohol or ethylene oxide proved stronger and thus possibly more suitable for use as graft material than those preserved by other methods. The increase in tensile strength produced by these agents was accompanied by a loss of elasticity of the vessel wall which was not produced by the other preservatives, and this fact may be considered to offset the increased suture-holding power. There is obviously little advantage in having a graft with strength greater than that of the recipient living vessel, and it is probably more important for its other physical properties to approximate to those of the recipient vessel, provided that its tensile strength is in no way impaired by the preservation.

*Table II.*—Mean Values in Each Preservation Group

| Preserving Agent | Breaking Strain | | | | | |
|---|---|---|---|---|---|---|
| | Aorta | Change produced | Percentage change | Inferior vena cava | Change produced | Percentage change |
| 1. Ringer-Locke | 94 g. | — | — | 209 g. | — | — |
| 2. Deep freeze | 135 g. | +41 | +44 | 188 g. | −21 | −10 |
| 3. Freeze-dried | 107 g. | +13 | +14 | 191 g. | −18 | −9 |
| 4. Formol-saline, 4 per cent | 96 g. | +2 | +2 | 147 g. | −62 | −30 |
| 5. Ethyl alcohol, 75 per cent | 205 g. | +111 | +118 | 151 g. | −58 | −28 |
| 6. Ethylene oxide | 203 g. | +109 | +116 | 139 g. | −70 | −33 |
| 7. F. Sal., Eth. ox. | 237 g. | +143 | +152 | 174 g. | −35 | −17 |

The main conclusion to be drawn from the results is that the simplest preservation method—namely, using 4 per cent formol-saline—is probably the best for an arterial graft. It will sterilize the graft and preserve its elasticity while slightly enhancing its suture-holding power. Using the same method for a vein graft will reduce its suture-holding power, but this will still be greater than that of the corresponding artery.

## SUMMARY

1. The aorta and inferior vena cava of rabbits have been preserved by different methods.

2. A method of measuring the suture-holding power of the vessels is described and the results obtained thereby are presented and discussed.

3. Formol-saline, 4 per cent, is the agent favoured, as it slightly enhances the suture-holding power of the aorta while maintaining its elasticity, and at the same time sterilizes the graft.

4. Ethyl alcohol, 75 per cent, and ethylene oxide rather more than double the suture-holding power of the aortic wall at the expense of its elasticity.

5. Freezing methods preserve the physical properties but necessitate an aseptic method for the preparation of the graft.

6. Rabbit vena cava has a greater holding power than the aorta in the fresh state, but tends to become weaker during preservation.

My thanks are due to Mr. J. B. Kinmonth, at whose suggestion this work was undertaken, and whose advice was so readily given throughout the work and the preparation of this paper; to Mr. H. G. Eastcott, of St. Mary's Hospital Medical School, for freeze-drying some of the material; and to Miss D. Aitken for her valuable technical assistance.

## REFERENCES

Eastcott, H. G., and Hufnagel, C. A. (1950), *Surgical Forum* (Amer. Coll. Surg.), **1**, 269. Philadephia: W. B. Saunders Co.

Guthrie, G. C. (1910), *Heart*, **2**, 115.

Hufnagel, C. A. (1953), Ciba Foundation Symposium.

— — Rabil, P. J., and Reed, L. (1953), *Surgical Forum* (Amer. Coll. Surg.), 162. Philadelphia: W. B. Saunders Co.

Levin, I., and Larkin, J. H. (1907), *Proc. Soc. exp. Biol., N.Y.*, **5**, 109.

Nakayama, K. (1953), Lecture at St. Bartholomew's Hospital.

Pierce, E. C., Rheinlander, H. F., Mortiz, A. R., Gross, R. E., and Merrill, K. (1949), *Amer. J. Surg.*, **78**, 314.

# EXPERIMENTAL MITRAL INCOMPETENCE IN DOGS: STUDIES IN HÆMODYNAMICS

G. R. CRAWSHAW, V. H. WILSON, L. KREEL, K. B. VETTEN, AND J. B. BORMAN
FROM THE CARDIAC SURGICAL RESEARCH UNIT: DEPARTMENT OF SURGERY, UNIVERSITY OF THE WITWATERSRAND*

THIS publication describes one of a series of investigations into the problems of mitral valve disease. (Crawshaw, Vetten, and Wilson, 1953; Wilson, Vetten, Crawshaw, and Knocker, 1954.) The total experience has been gained during experimental surgery upon 55 dogs.

The ultimate purpose of the investigations is to explore the possibilities of reconstructive surgery in mitral incompetence.

In a previous publication (Crawshaw and others, 1953) the surgical anatomy of the mitral valve was studied and a method for the production of experimental mitral incompetence in the dog with survival was presented. We have also described (Wilson and others, 1954) the various extrinsic and intrinsic factors which we have found responsible for influencing recording from left and right auricles and systemic arteries, using strain gauge amplification and Statham transducers.

This present investigation was undertaken to examine the effects upon the left auricular and pulmonary venous pressures of: (1) the creation of experimental mitral incompetence of varying severity; (2) inducing a transient systemic hypertension by compression of the ascending and descending aorta; (3) the addition of aortic incompetence to the mitral incompetence; (4) transient systemic hypertension after the creation of the combined incompetent lesions of mitral and aortic valves.

Objective pressure changes in the left auricle before and after operation upon the mitral valve may be inconclusive in the human (Wynn, Mathews, McMillan, and Daley, 1952).

## MATERIAL AND METHODS OF INVESTIGATION

The information for this present investigation has been collected during experimental thoracotomy upon 15 mongrel dogs of both sexes varying in weight from 31 lb. to 92 lb.

The essentials of the surgical and the anæsthetic procedures (Crawshaw and others, 1953) and the methods of E.C.G. and pressure recording (Wilson and others, 1954) have been described previously. Mitral incompetence has been created either by suturing back chordæ tendineæ of the mitral valve to the left ventricular wall or by cutting various chordæ of the valve with a special curved knife designed for the purpose. The chordæ for suturing or cutting were selected by a finger in the left heart chambers which guided the suture or the knife in this selection. The aortic cusps were cut or perforated with the same knife, which was introduced through an incision in the ascending part of the aortic arch. Concurrently with the pressure recording, independent clinical estimates of the blood-flow, such as regurgitant jets and associated thrills, as well as the extent of the valvular damage, were made by the surgeon.

Transient artificial hypertension was caused by compressing the descending aorta against the body of the sixth dorsal vertebra so as to occlude the vessel completely. The other hypertensive test was made by tightening a tourniquet around the aorta between the coronary arteries and the right innominate artery.

The anæsthetic has been standard (Crawshaw and others, 1953) and designed to prevent as far as possible deterioration in the general condition, to maintain the efficiency of the circulation of the animal, and to provide a constantly controlled ventilatory state during E.C.G. and pressure recording.

In some of the cases relaxants in small doses have been administered to suppress all respiratory movement without affecting the general condition of the animal. As previously described (Wilson and others, 1954) changes in the general condition of the animal can alter the venous pressures and patterns considerably and become a serious source of confusion if not respected.

Balancing of the amplifiers and calibration of the transducers has been without difficulty and the sensitivity of the instruments has remained unchanged throughout hours of experiment. Calibration has been standardized in all cases to satisfy the needs of the pressure sources. The speed of running the Sanborn 'Permapaper' has varied from 25 to 50 mm. per second, and various degrees of signal attenuation have been used in order to clarify the relationships between the venous pattern, the carotid pressure tracings and the E.C.G. complexes. The length of the polythene No. 3 catheter for the venous recording has invariably been 100 cm. The systemic arterial catheter was introduced into the left common carotid and the tip placed near the aortic arch. During thoracotomy the venous catheter was introduced into one of the subsidiary pulmonary veins and advanced to positions in a principal pulmonary vein or in the left auricular chamber for the pressure recording. The reference point for the pressures has been adjusted to the middle of the dorsal spine with the animal lying in the right lateral position.

The several factors previously found responsible for disturbing the fidelity of the venous pressure recording (Wilson and others, 1954) have throughout been respected before the tracings were considered to be standard. The venous pressures have been considered for both height of pressure and the appearances of the 'a', 'c', and 'v' components of the cardiac venous cycle of MacKenzie (1925).

All the dogs have been sacrificed after the investigation and a detailed macroscopical necropsy study of the valves, endocardium, and myocardium has been made. In no case has there been evidence

* Supported by a monetary grant from the Nuffield Foundation.

of inflammatory or other disease. The extent of the surgical damage to the mitral and aortic valves has been recorded in detail and photographed. The description of the anatomical changes created in the mitral valve by operation has been based on

## RESULTS

**Observations Before Mitral Valve Damage.**—1. *Basal.*—The 'a', 'c', and 'v' wave components of the venous cycle were not invariably present, especially with low attenuation of the pressure signal,

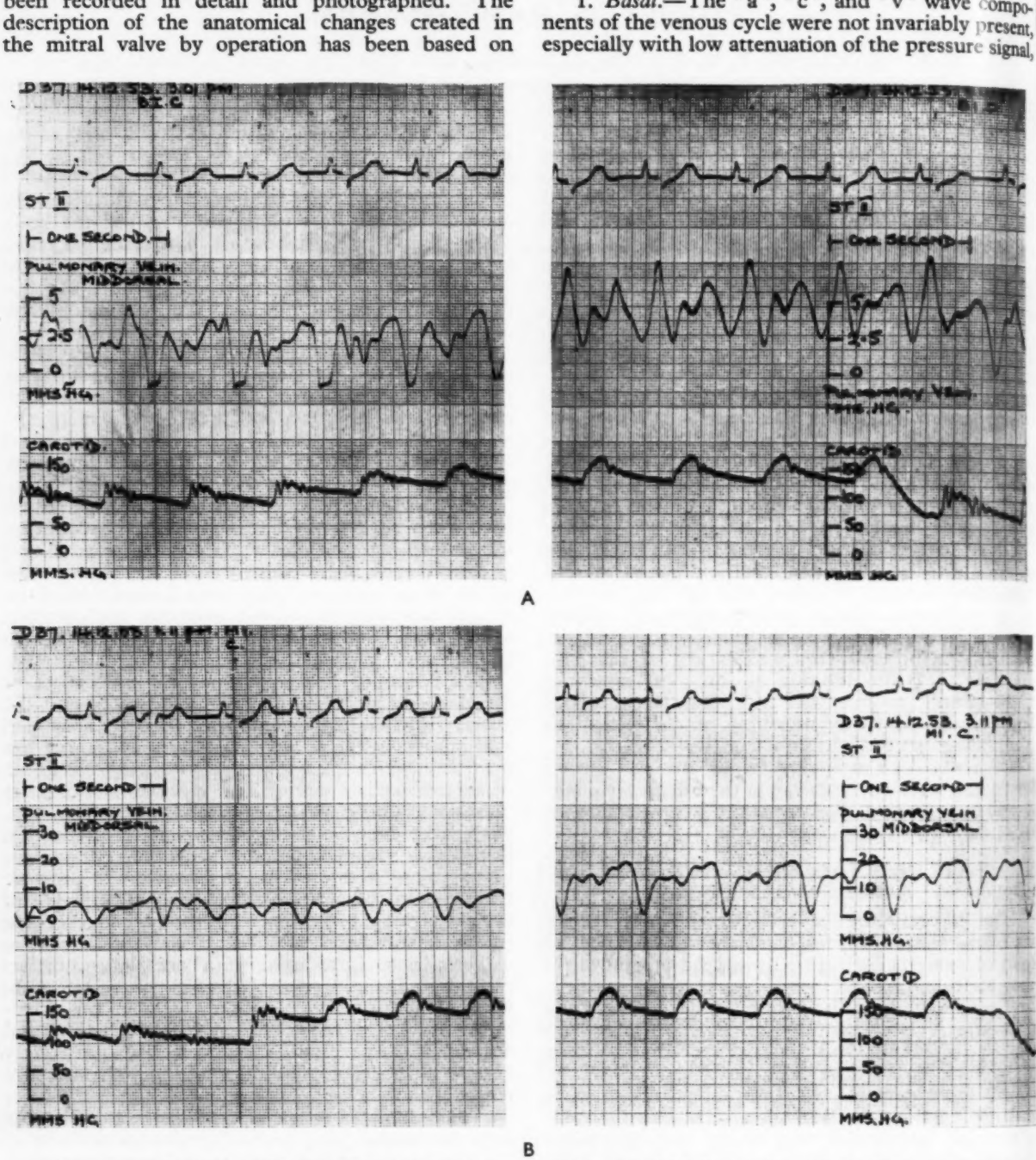



FIG. 373.—A–C, E.C.G., pulmonary venous and carotid pressure tracings recorded before, during, and after the hypertensive test produced by the complete compression of the descending aorta, with the normal mitral valve, after mitral incompetence alone, and after the combined mitral and aortic incompetence. The period of the hypertensive test is reflected in the change in carotid pressure. A, Tracings with the normal mitral valve. Towards the end of the hypertensive test the 'a' wave of the pulmonary venous tracing is clearly preponderant. (The central part of the tracing for a period of 4 sec. has been removed.) B, Tracings after mitral incompetence created by suturing to the left ventricular wall a major chorda to the lateral 'critical area' of the posterior cusp (*see* D). Under basal conditions a very soft jet was noted within the left auricle, but no thrill on the surface of the heart. The jet became more marked and a

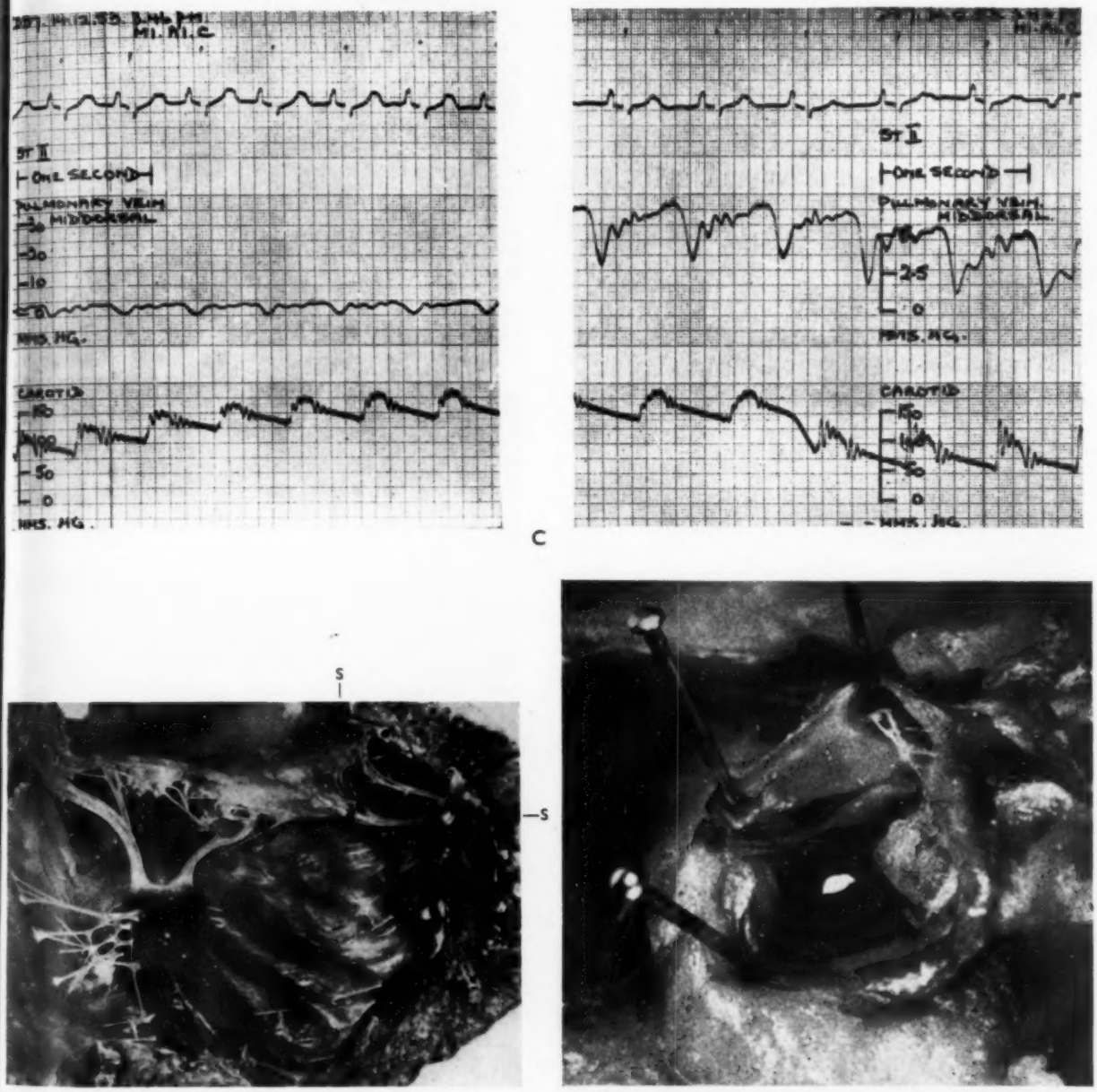
Brock's account of the attachment of the chordæ tendineæ to the valve cusps (1952).

The same surgeon, anæsthetist, and physician have been responsible for the operative and recording procedures.

when often the pattern has been poorly defined with but two ill-defined waves. The characteristics of the venous cycle have usually been clarified by increasing the attenuation of the signal and increasing the running speed of the recording paper (*Fig.* 373).

A well-pronounced and constant regurgitant jet was felt within the auricle and a thrill on the surface in one case only, which, at necropsy, was found to have a normal heart in all respects (*Fig.* 374). It is of interest in this connexion that MacKenzie (1925) believed mitral regurgitation to occur on occasion in normal human hearts.

2. *During the Transient Hypertensive Tests.*—The left auricular and pulmonary venous tracings have usually shown a steady rise in pressure during the test either with or without a change in the pulse pressure (*Fig.* 375). All components of the venous cycle have become more pronounced, the 'a' wave being predominant (*Figs.* 373, 374) in all except one dog (No. 42). In this dog, when a jet was felt at the end of the test, the 'v' wave equalled the 'a' wave in height (*Fig.* 376). In another case, reported above, when a mitral regurgitant jet was felt under basal conditions the 'a' wave remained predominant throughout the hypertensive test (*Fig.* 374).




thrili appeared on the surface during the hypertensive test. At the end of the test the 'c' and 'v' waves have become preponderant over an insignificant 'a' wave. (The central part of the tracing for a period of 4 sec. has been removed.) C, Tracings after the creation of an aortic incompetence in addition to the mitral incompetence (*see* E for the aortic lesion). The aortic damage is reflected in the increase of pulse-pressure in the carotid tracing as compared with that seen with the single lesion. The attenuation of the pulmonary venous pressure has been altered in the middle of the recording to accentuate the characteristics of the pattern—namely, preponderance of the 'v' wave over the 'a' wave. (The central part of the tracing for a period of 5 sec. has been removed.) D, Dog 37. Mitral lesion. Chordæ to the lateral critical area of the posterior cusp retracted by black silk stitch. E, Dog 37. Aortic lesion. Tear in the right posterior cusp. S, Stitch.

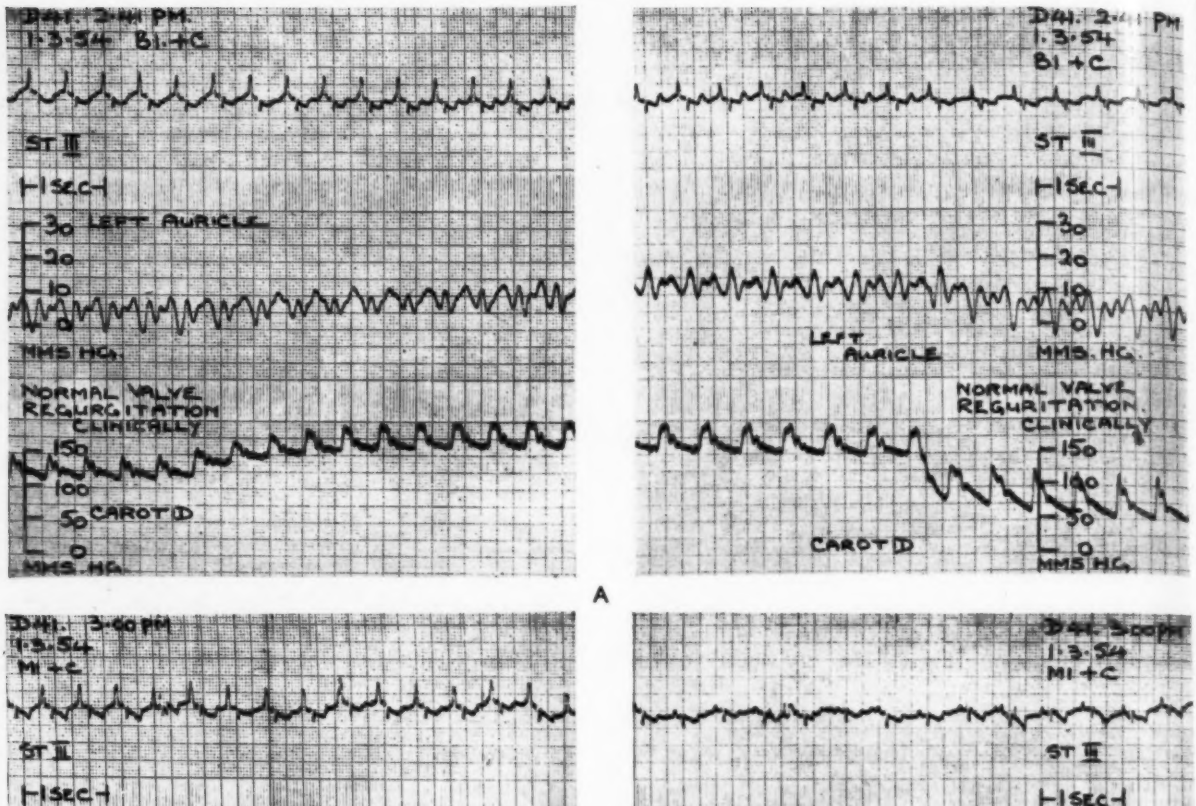


FIG. 374.—A, B, E.C.G., left auricular, and carotid pressure tracings recorded before, during, and after the hypertensive test produced by the complete compression of the descending aorta, with the normal mitral valve and after the function of the mitral valve had been modified to give minimal incompetence. The period of the hypertensive test is reflected in the change in carotid pressure. A, Tracings with the normal mitral valve which showed evidence of incompetence in the clearly felt jet within the left auricle both before and during the hypertensive test. In this case the left auricular tracing did not reflect the incompetence observed by the surgeon, i.e., the 'a' wave has remained preponderant throughout the hypertensive test. (The central part of the tracing for a period of 3 sec. has been removed.) B, Tracings after mitral incompetence created by suturing to the left ventricular wall four chordæ near the lateral 'critical area' of a large posterior cusp. The regurgitant jet was only observed to be very small. The 'v' wave in the left auricular tracing became prominent and higher than the 'a' wave towards the end of the hypertensive test. (The central part of the tracing for a period of 4 sec. has been removed.) C, Dog 41. Mitral lesion. Black silk stitch placed around four chordæ to the lateral portion of the posterior cusp near the critical area. S, Stitch.

**Observations after Acute Damage to the Mitral Valve.—**

1. *Basal.*—We agree with Brock (1952) that the 'critical areas' of attachment of the chordæ tendineæ or pattern (*Fig.* 373). Under these circumstances only slight regurgitant jets have been felt within the auricle. When a 'critical area' of either mitral cusp has been made ineffective, gross changes in

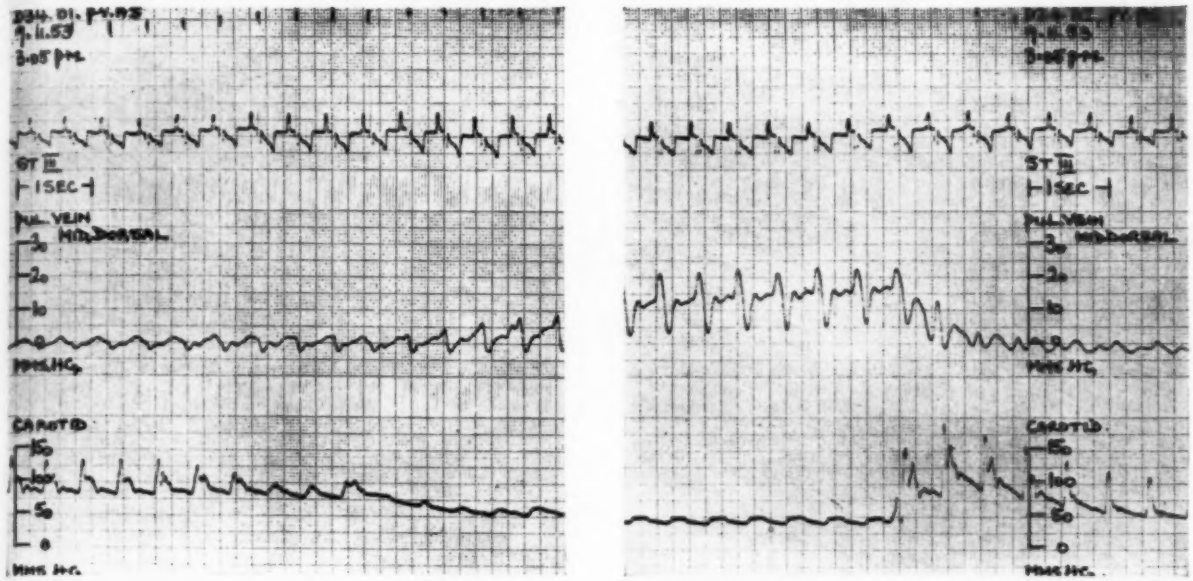



FIG. 375.—E.C.G., pulmonary venous, and carotid pressure tracings recorded before, during and after the hypertensive test produced by the compression of the aortic root with the normal mitral valve. Neither jet nor thrill was noted at any time during the record. The pulmonary venous tracing shows what is considered to be the normal response to the hypertensive test—namely, an increase in the height of the pressure with preponderance of the 'a' wave. The period of the hypertensive test is reflected in the change in carotid pressure. (The central part of the tracings for a period of 4 sec. has been removed.)

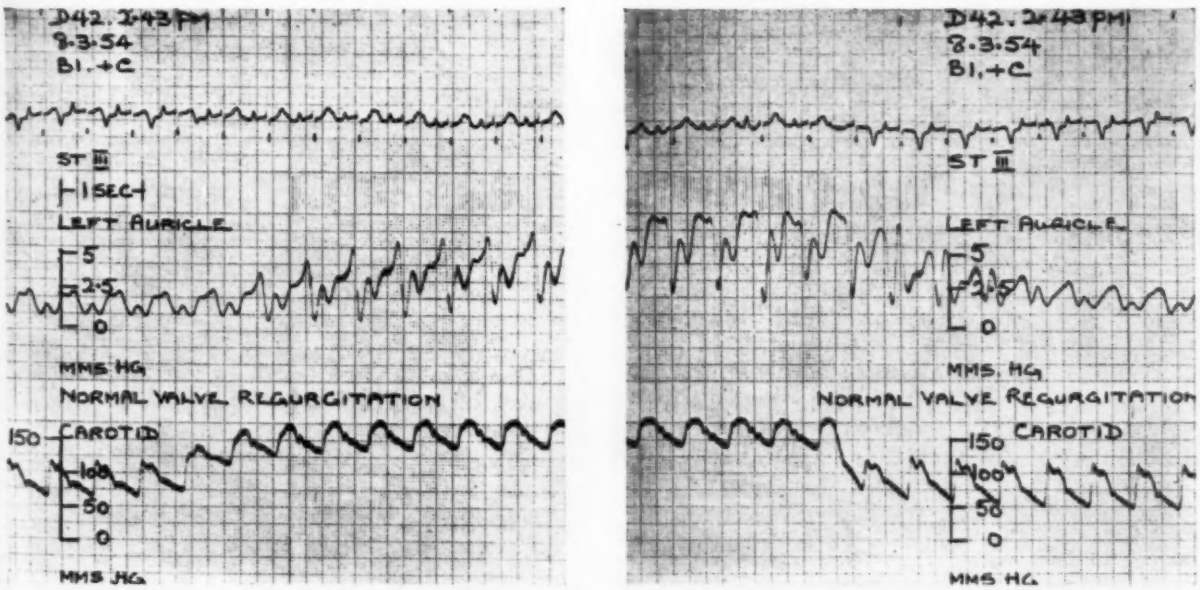
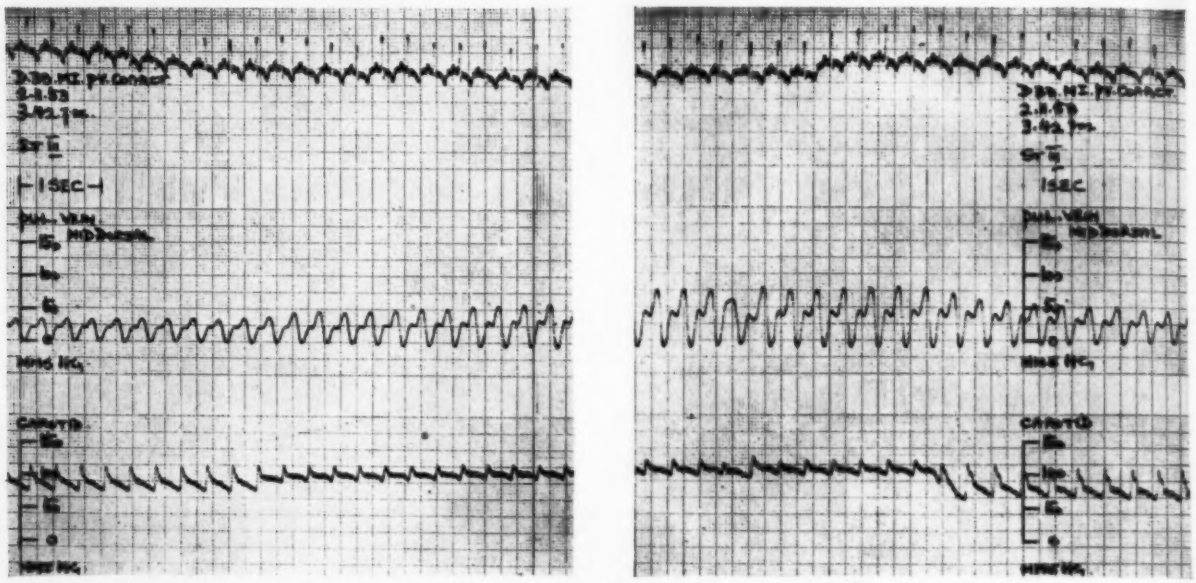



FIG. 376.—E.C.G., left auricular, and carotid pressure tracings before, during, and after the hypertensive test produced by compression of the descending aorta with a normal mitral valve. Towards the end of the hypertensive test a jet was noted within the auricle and a thrill on the surface of the heart. The pattern of the left auricular pressure reflected this incompetence noted by the surgeon in the preponderance of the 'v' wave over the 'a' wave also to be observed towards the end of the hypertensive test. The period of the hypertensive test is shown by the change in the carotid pressure. (The central part of the tracing for a period of 2 sec. has been removed.)

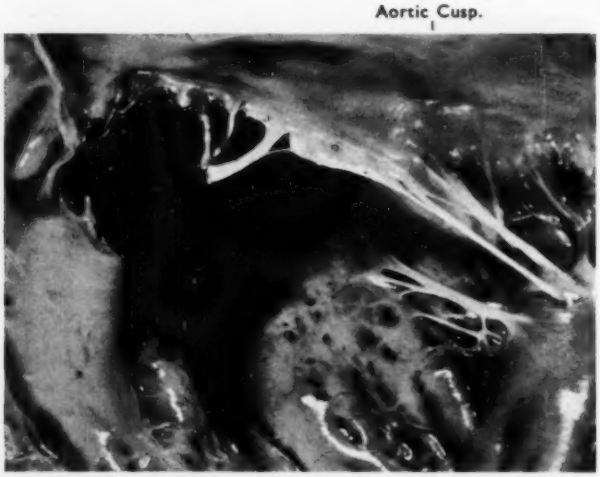
to the cusps are of the greatest importance in mitral valve function. In our experiments when the less important areas of the cusps have been rendered ineffective there has been little or no effect upon the pulmonary venous or left auricular pressure height both height and pattern of the venous pressure have occurred associated with palpable regurgitant jets in the auricle and obvious thrills on the surface of the heart. At the same time the left auricle and the pulmonary veins have become distended. In one

case the systolic auricular pressure was comparable in height with that in the carotid artery (*Fig.* 377). After damage to the ' critical areas ' the ' c ' and/or ' v ' waves have been invariably and strikingly predominant.

2. *During the Transient Hypertensive Tests.*—Comparison of the simultaneous venous and systemic arterial pressure records during hypertensive tests after the creation of either *slight* or *gross* mitral incompetence revealed important features. In the presence of *minimal* valve damage a palpable systolic thrill on the surface of the atrium might only become evident during the application of the test and at the same time the ' c ' and ' v ' components of the venous cycle become strikingly predominant over an inconspicuous ' a ' wave (*Fig.* 373). In those cases with *gross* damage to the mitral cusps the ' ventricular ' venous tracing of MacKenzie has been apparent (*Fig.* 378). In one case compression of the ascending aorta evidently caused further damage to change minor into major mitral incompetence.




A




B

FIG. 377.—A, E.C.G., pulmonary venous and carotid pressure tracings before, during, and after the hypertensive test by compression of the descending aorta following the creation of a gross mitral incompetence by the cutting of chordæ to a ' critical area ' of the anterior cusp (*see* B). A powerful regurgitant jet was noted within the left auricle and a strong thrill on the surface of the heart. These observations made by the surgeon were reflected in the pulmonary venous tracing, which showed a very large increase in pressure, comparable to that of the carotid, and in the large ' c ' and ' v ' waves. The period of the hypertensive test is indicated by the change in the carotid pressure. (The central part of the tracing for a period of 4 sec. has been removed.) B, Dog 33. Mitral lesion. Chordæ to the lateral critical area of the aortic cusp have been divided.

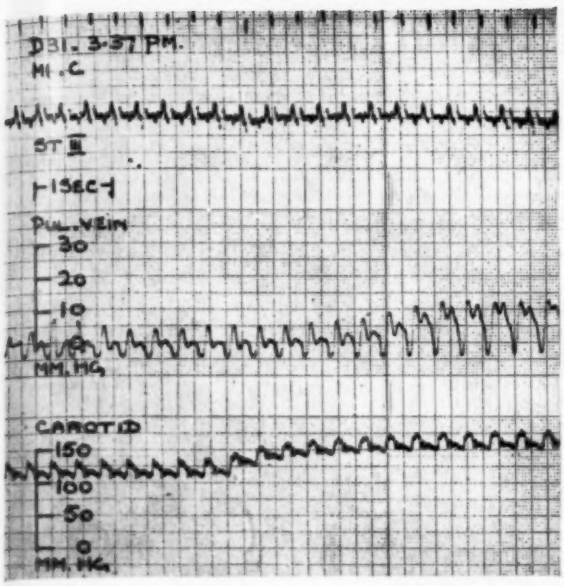
**Observations after Damage to Both Mitral and Aortic Valves.—**

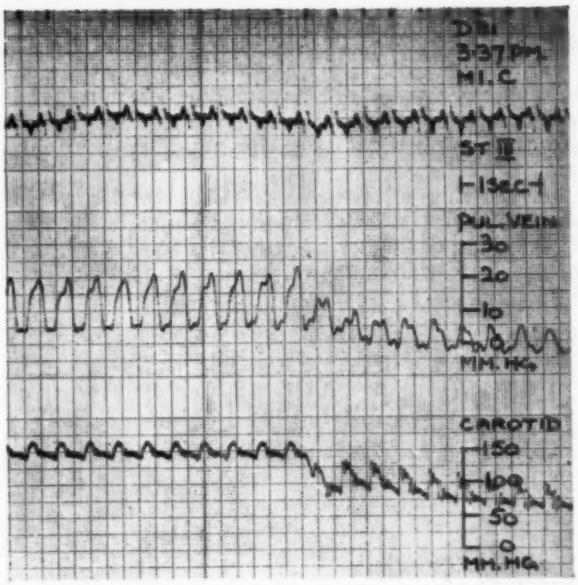
1. *Basal.*—Although gross damage to one cusp of the aortic valve (AI) has been reflected in the carotid pressures, there has in some cases been little or no effect on the left auricular and pulmonary venous pressures when this degree of aortic damage has been combined with mitral incompetence of relatively minor degree (mi) (*Fig.* 378). With gross combined lesions (AI + MI) hypertension has occurred behind the mitral valve and predominance of the ' c ' and ' v ' waves as with the single severe mitral lesion.

2. *During the Hypertensive Tests.*—Essentially similar clinical and pressure height and pattern changes were noted with the combined incompetent lesions as with mitral incompetence alone. (*Fig.* 378.)

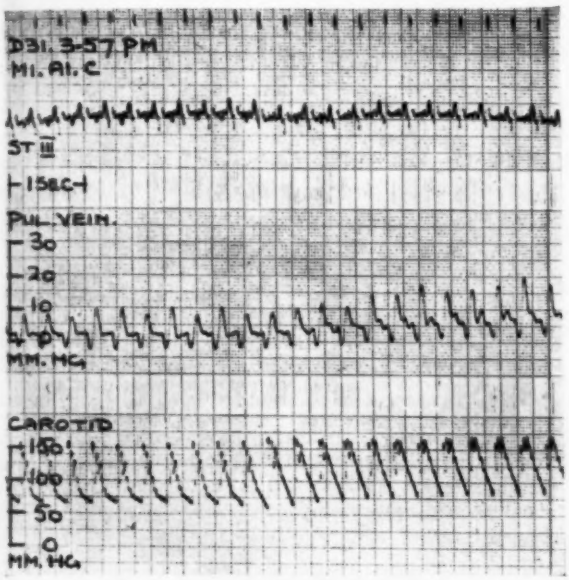
**Cardiac Rhythm.**—During these investigations sinus rhythm has been the rule. In one case, before valvular damage, ventricular extrasystoles occurred to alter the left auricular pressure pattern, giving large ' v ' waves. In another, following combined mitral and aortic incompetent lesions sinus rhythm was replaced by fibrillation of the left auricle, whereupon the pressure pattern corresponded to the records of MacKenzie during auricular fibrillation—namely, they showed absence of the ' a ' wave.

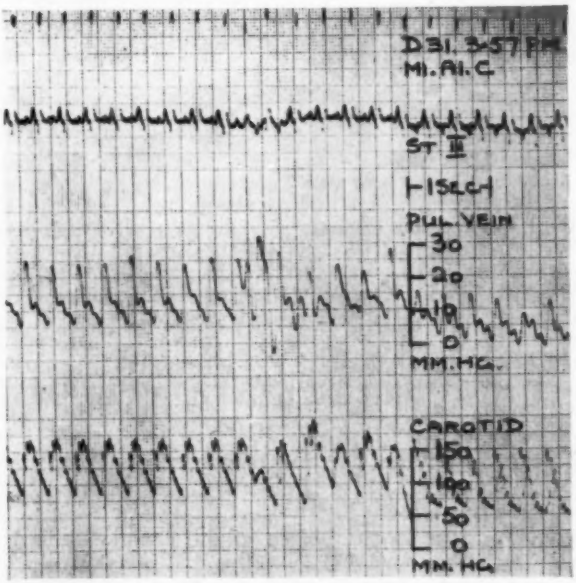
**Electrocardiographic Records.**—During none of these experiments, each of which lasted about




A




B

C

D

ANTERIOR

FIG. 378.—A, B, E.C.G., pulmonary venous and carotid pressure tracings before, during, and after the hypertensive test produced by compression of the descending aorta after the creation of a mitral incompetence alone, and after a combined mitral and aortic incompetence. The period of the hypertensive test is indicated by the change in the carotid pressure. A, Tracings after mitral incompetence by tearing away the chorda to the lateral 'critical area' of the posterior cusp. A small thrill was noted on the surface of the heart under basal conditions. This became more marked during the hypertensive test. Towards the end of the hypertensive test the 'ventricular' venous pattern of Mackenzie is to be observed. (The central part of the tracing for a period of 5 sec. has been removed.) B, Tracings after the creation of an aortic incompetence in addition to the mitral incompetence. The aortic damage is reflected in the gross increase of pulse-pressure in the carotid tracing as compared with that seen with the single lesion. (The central part of the tracing for a period of 5 sec. has been removed.) C, Dog 31. Mitral lesion. The major chorda to the lateral critical area of the posterior cusp has been torn medially so as to be slack and ineffective. D, Dog 31. Aortic lesion. A large hole in the anterior cusp.

three hours, was there any change in the electrocardiographic patterns except when hypertensive tests were applied. Under these conditions minimal changes occurred :—

*a.* Slowing of the heart : This conforms with Marey's law. When hypertension is caused by compression of the aorta against the body of the sixth thoracic vertebra the carotid sinus is stimulated and

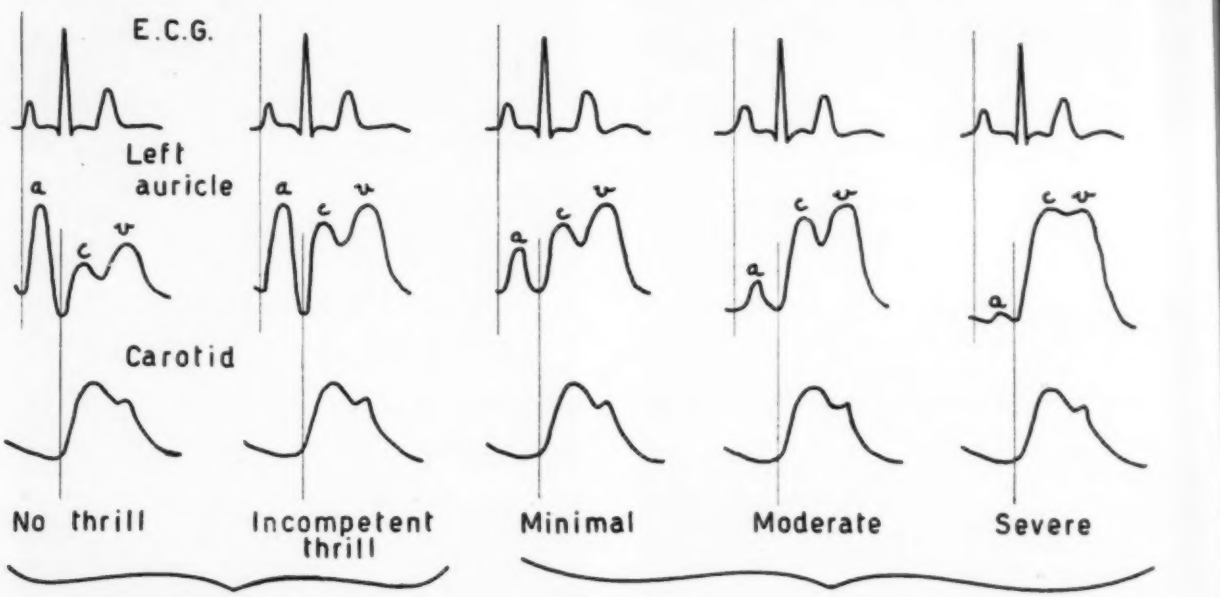



FIG. 379.—Diagrammatic representation of left auricular pressure tracings with E.C.G. and carotid pressure records during hypertensive tests with the normal mitral valve and with varying degrees of mitral incompetence created surgically.

there occurs reflex slowing of the heart (*Figs.* 373, 374). Compression of the aorta at its root does not produce the effect (*Fig.* 375).

*b.* Increase in the height of the R wave in leads AVF and Standard III.

*c.* Changes in direction or depth of the end portion of the T wave which could be interpreted as accentuation of the U wave. Following the release of the aortic compression these changes rapidly disappear, but sometimes the first few beats after release show more marked inversion of the T wave (*Figs.* 375, 378).

*d.* Occasional decrease in the size of the P wave formation of ectopic P (*Fig.* 374, MI + C, last beat) or auricular extrasystoles (*Fig.* 374, MI + C, third beat).

The above changes also occur prior to the production of valvular lesions and are therefore related to the hypertensive effect rather than to any valvular abnormality.

A full report of the electrocardiographic changes during experimental cardiac surgery is being prepared.

## CONCLUSIONS

1. Under basal conditions and in the acute experiment little or no change in the height or the pattern of the left auricular and pulmonary venous pressures occurs until the function of one of Brock's 'critical areas' of attachment of chordæ to the mitral valve cusps has been affected by surgical intervention.

2. Transient systemic hypertension produces characteristic changes in the left auricular pressure patterns which make the recognition of the less gross forms of mitral incompetence possible (*Fig.* 379). The more simple test of compressing the descending aorta was found to be quite as effective in revealing these distinguishing features as was compression of the aortic root.

3. As judged from necropsy study and the pressure pattern changes after the creation of mitral incompetence, the surgeon's finger is very sensitive in appreciating the regurgitant jet in both minor and major degrees of mitral incompetence.

4. Under basal conditions and also during transient hypertensive tests, the normal mitral valve shows, in some cases, evidence of incompetence.

5. Considerable degrees of aortic incompetence can be added to mitral incompetence without significantly affecting the left auricular and pulmonary venous pressure height or pattern.

## SUMMARY

The hæmodynamics of the left auricle have been studied before and after the creation of mitral incompetence alone, and combined with aortic incompetence as an acute experiment in 15 dogs.

Simultaneously electrocardiographic tracings and systemic arterial, left auricular, and pulmonary venous pressure records have been made with the strain gauge amplifier and Statham transducer, firstly under basal conditions and secondly with transient systemic hypertension produced by compression of the aorta. Clinical and necropsy observations have been made and correlated with these records.

Attention has been drawn to previous experience with 55 dogs and to publications which have made it possible to evaluate these procedures.

We are grateful to Professor W. E. Underwood for granting us facilities in his department and for his enthusiastic interest in our work. We are indebted to Mr. L. Fatti for his inspiration and guidance. We thank Dr. J. C. Nicholson, Head of the Department of Anæsthesia, for his help.

This work could not have been done without the skilled assistance of Mr. R. L. Caunter, R.M.T., and Mrs. S. McNeill, S.R.N.

For the fine quality of the photography we thank Mr. T. Marais.

REFERENCES

BROCK, R. C. (1952), *Brit. Heart J.*, **14**, 489.
CRAWSHAW, G. R., VETTEN, K. B., and WILSON, V. H. (1953), *S. Afr. J. med. Sci.*, **18**, 79.
MACKENZIE, Sir JAMES (1925), *Diseases of the Heart*, 4th ed. London: Oxford University Press.
WILSON, V. H., VETTEN, K. B., CRAWSHAW, G. R., and KNOCKER, P. (1954), *S. Afr. J. med. Sci.*, **19**, 1.
WYNN, A., MATHEWS, M. B., MCMILLAN, I. K. R., and DALEY, R. (1952), *Lancet*, **2**, 216.

# *SHORT NOTES OF RARE OR OBSCURE CASES*

## FIBROCYSTIC SALIVARY TUMOUR OF THE MANDIBLE

BY ALISTER J. M. MATHIESON, LONDON

SALIVARY gland tissue has been found very rarely within the bony structure of the mandible, most usually in the form of 'mixed' salivary tumours (Ward and Kendrick, 1950), but the occurrence of a cyst of the mandible with origin in salivary gland tissue does not appear to have been previously reported. The following case seems worthy of record.

### CASE REPORT

A 54-year-old man, a roundsman by trade, was admitted to Hammersmith Hospital in November, 1953, having been referred by a dentist. He gave a ten-year history of pain, nagging in character and constantly present, in the left lower jaw. There was no other complaint.

General examination revealed a well-built and well-nourished healthy middle aged man. On local examination a diffuse swelling on the medial aspect of the lower jaw, over the angle and extending forwards 1 in. was seen. Its surface was smooth and its edge merged evenly into the contours of the mandible; it felt stony hard. Pressure produced local pain. There was gross dental caries throughout the mouth, but no teeth were present in this part of the jaw. There was no trismus.

X-ray examination of the mandible showed a thin-walled smooth cyst in the ascending mandibular ramus expanding the bone and, at one point on its upper surface, a very small section breaking through the thin cortex (*Fig.* 380).

A radiological diagnosis of dental cyst was made.

Exploration was performed by the intra-oral route. The summit of the swelling in the mouth was represented by a tough and rather pale area of mucous membrane measuring 4 × 2 cm. and situated on the medial aspect of the posterior extremity of the lower alveolus on the left side. When the summit was removed a cystic cavity was discovered with apparent complete destruction of the cortex on the medial aspect of the bone. The tumour was in part solid and part cystic. The line of demarcation between the cyst and mandible was sharp. The roof of the cyst was removed and after nibbling away the margins of the bone its lining epithelium was completely excised. The cavity was then found to communicate with the loose tissues of the neck below and behind the angle of the mandible. The cavity was loosely packed with 'Vaseline' gauze. The post-operative course was without event, the cavity being kept loosely packed until complete healing resulted. His pain was completely relieved.

Macroscopical examination of the removed tissue showed a tumour with an irregular surface, partly solid and partly cystic, the cysts being 3–4 mm. in diameter and filled with mucinous material. On histological examination the tissue at one end of the specimen was composed of muscle, fat, blood-vessels, nerves, and mucus-secreting salivary tissue which was normal except for some distension of the ducts. This tissue was continuous with very dense fibrous tissue in which lay embedded small and large cystic spaces lined by normal and metaplastic salivary duct and acinar epithelium. Some of the cysts contained mucin which in places had leaked out into the stroma. A focus of reaction to old hæmorrhage was also seen. No bone trabeculæ were present in the fibrocystic area. Sections of other portions of the specimen showed normal buccal epithelium overlying cystic salivary tissue, fibrous and muscle tissue; a few normal bone trabeculæ were present in these sections (*Figs.* 381–383). All of the salivary tissue was of mucus-secreting type; no serous secreting salivary tissue was present throughout the specimen.

A post-operative sialogram showed a normal left submandibular duct and gland (*Fig.* 384).

### DISCUSSION

Theoretically, salivary gland tissue within the bony structure of the mandible might arise from metaplasia of the epithelial appendages or more probably from inclusion of salivary tissue within the bone in the course of development.

Assuming the inclusion theory to be correct, the ectopic salivary tissue may originate in either buccal glands or submandibular salivary gland. The buccal salivary glands are lined by mucus-secreting cells only, whereas both mucus- and serous secreting cells are present in the submandibular salivary gland. The fact that the tissue was of mucus cell type only does not, however, exclude an origin in submandibular gland, as the salivary glands do not show histological evidence of serous secretion until

after birth, although mucin is secreted much earlier (Hamilton, Boyd, and Mossman, 1945). It is suggested that enclosed within the mandible a portion of submandibular gland might well remain in its primitive state and fail to differentiate into serous tissue.

unlikely to become included within the bone, although it is admittedly conceivable that some of the glands might do so. The submandibular salivary gland arises as an epithelial ridge from the buccal epithelium in the floor of the mouth in close proximity

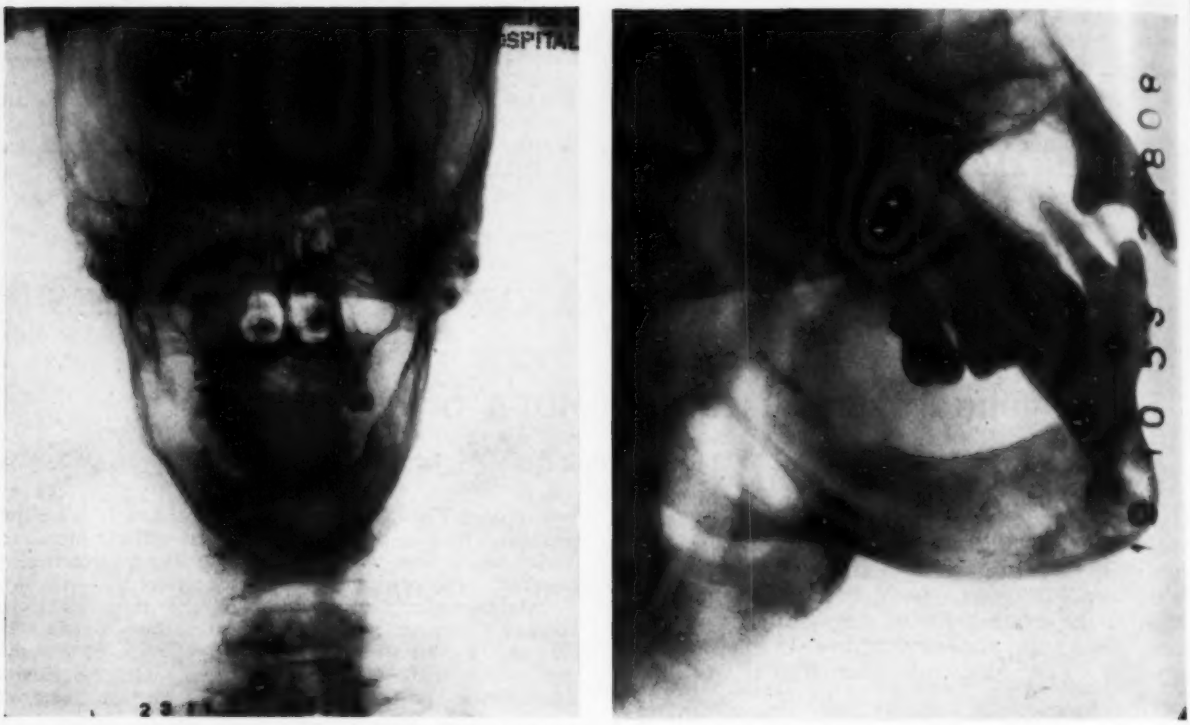


FIG. 380.—Anteroposterior and oblique radiographs of the mandible showing a thin-walled smooth cyst in the ascending ramus, expanding the bone, and at one point in its upper surface breaking through the thin cortex.

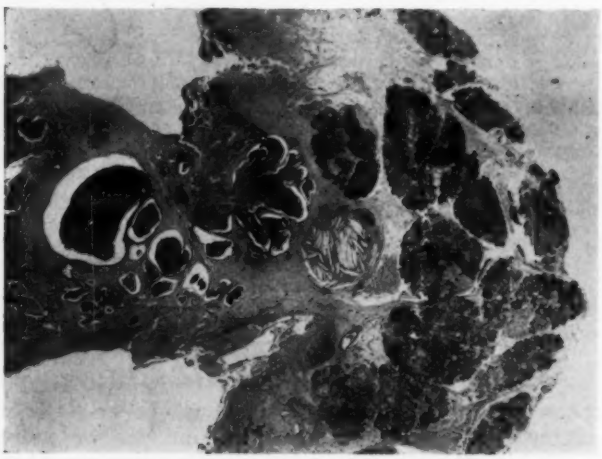


FIG. 381.—Photograph showing mucus-secreting salivary gland tissue with dilated and distended duct systems and considerable fibrous tissue. Also in the field are a few fragments of bone and a rounded mass filled with cholesterol clefts. (× 5·5.)

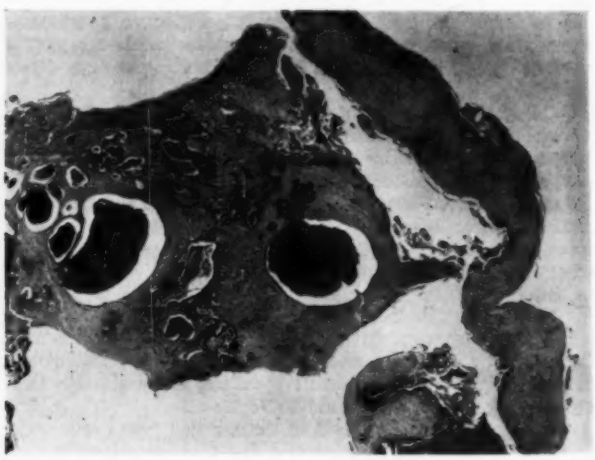


FIG. 382.—Photograph showing distended abnormal duct systems. (× 5·5.)

On embryological grounds also this theory of origin would appear most probable. The bony mandible arises first lateral to Meckel's cartilage and grows medially to surround it. The buccal glands lying in the buccal submucosa on the deep surface of the buccinator (Johnson and Willis, 1946) and lateral to the developing mandible would seem to the medial aspect of the developing mandible and gradually separates from the buccal epithelium to appear as a cord in the mesoderm of the floor of the mouth. As the bony mandible grows around Meckel's cartilage from the lateral side, it seems possible that it might include within its substance a portion of the submandibular gland rudiment (*Fig.* 385). Origin in Chiewitz's organ may also be considered, but as it also lies lateral to the developing

mandible it is difficult to imagine its inclusion within the bony structure.

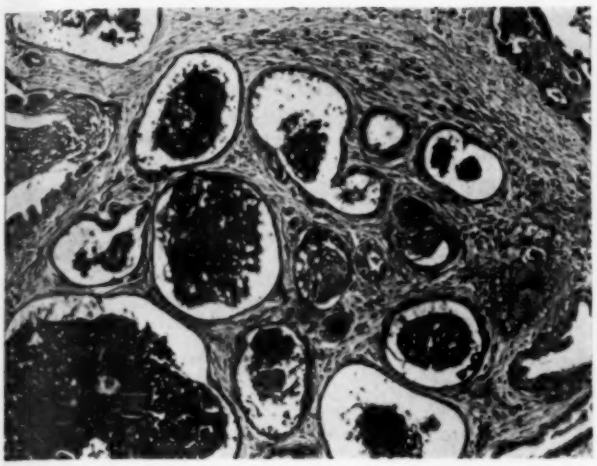


FIG. 383.—High-power view of duct systems showing abnormal epithelium with areas of squamous metaplasia and periductal fibrous tissue. (× 80.)

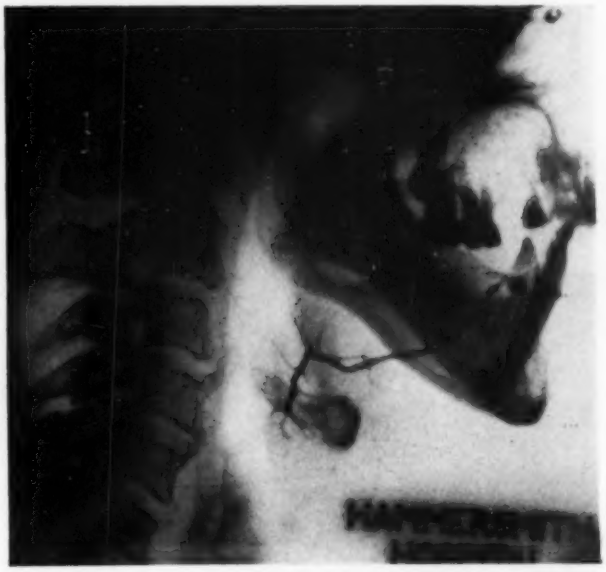


FIG. 384.—Post-operative sialogram showing a normal submandibular duct and gland.

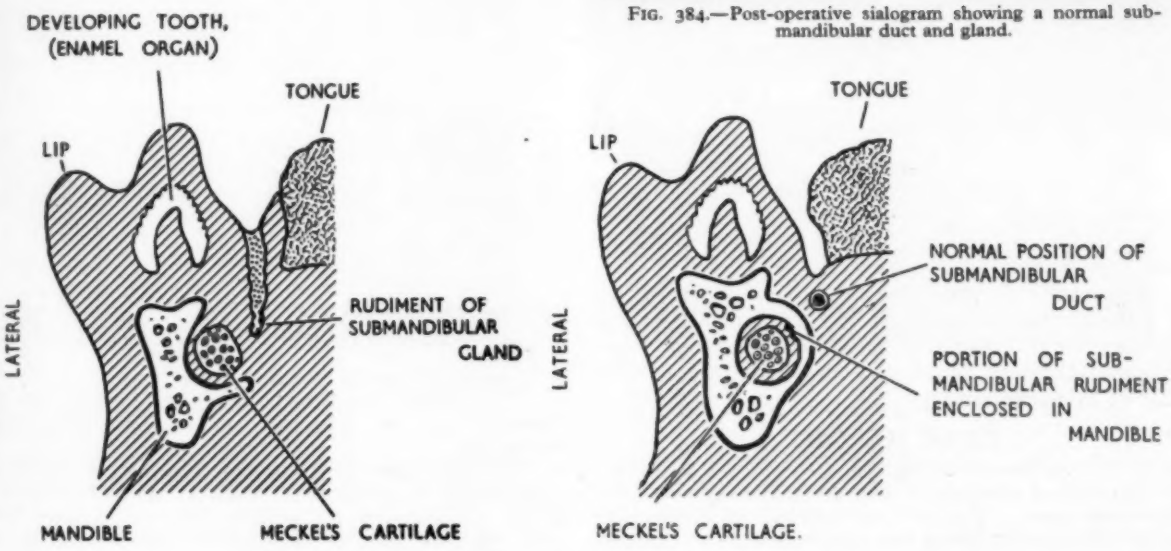



FIG. 385.—Coronal sections through developing floor of mouth, mandible, and tongue. A, The developing mandible growing medially to surround Meckel's cartilage. B, With further growth the mandible completely surrounds Meckel's cartilage; a portion of submandibular salivary gland rudiment is shown enveloped by the mandible.

## SUMMARY

A case of fibrocystic salivary tumour of the mandible is described and origin from undifferentiated submandibular salivary gland tissue is postulated. Removal of the summit of the cyst along with its superior bony margins and excision of the epithelial lining of the cyst was successful in obtaining rapid and complete healing of the cavity with complete relief from pain.

I wish to thank Dr. J. D. B. MacDougall, of the Anatomy Department in the University of St. Andrews, and Drs. R. E. Steiner and J. D. Taylor, of this school, for their help in the preparation of this paper, and also the Department of Medical Illustration in the school.

## REFERENCES

HAMILTON, W. J., BOYD, J. D., and MOSSMAN, H. W. (1945), *Human Embryology*. Cambridge: W. Heffer & Sons.

JOHNSON, T. B., and WILLIS, J. (1946), *Gray's Anatomy*. London: Longmans, Green & Co.

WARD, G. E., and HENDRICK, J. W. (1950), *Tumours of the Head and Neck*. Baltimore: The Williams & Wilkins Co.

# DUODENORENAL FISTULA: A COMPLICATION OF PEPTIC ULCERATION

By FRANCIS E. STOCK

PROFESSOR OF SURGERY, UNIVERSITY OF HONG KONG

FISTULOUS connexion between the duodenum and the renal pelvis and calices is a condition of extreme rarity, and although its occurrence is mentioned in radiological text-books such as that by Shanks and Kerley (1950) illustrations are not given and details are not quoted. The only case which has been brought to the author's notice was one published by

FIG. 386.—Intravenous pyelogram, right side, oblique view.

Capon and Wells (1938) in which a child swallowed a 'Kirby-grip' which ulcerated through the duodenum into the pelvis of the kidney. In the case reported here the fistula occurred as a complication of a penetrating duodenal ulcer which had become adherent to the anterior surface of the kidney and ulcerated through renal substance into the middle calix of the right kidney.

## CASE REPORT

C. Y. 65/53. Male, age 22.

The patient complained of pain in the right loin for about two years. The pain had commenced insidiously, was stabbing in character, and remained localized without radiation. During the last two months it had been of sufficient severity to make manual labour impossible. The pain occurred at intervals of 2–4 days, each attack lasting for about eight hours. During the attack there was nausea and occasionally vomiting. At the beginning micturition was normal, but recently there was increased frequency, approximately hourly day and night. The volume was not increased and the urine appeared to the patient to be normal. During the last year the patient had lost approximately 10 lb. of body-weight. Twelve months before admission appendicectomy had been performed in another hospital.

ON EXAMINATION.—The general condition was satisfactory, the only abnormal physical finding being a moderately severe anæmia with hæmoglobin of 7·0 g. Examination of the abdomen revealed a well-healed appendicectomy scar, a scaphoid abdomen with no visible or palpable masses but tenderness in the right loin and right hypochondrium. The urine was acid and contained a few red blood-cells and pus cells.

Radiography of the chest showed calcified right hilar glands. A straight film of the abdomen showed two small round opacities in the right hypochondrium thought to be gall-stones. An I.V.P. showed good function on both sides, with a normal left kidney. The pelvis of the right kidney was not seen and the upper calix appeared slightly dilated. The opacities previously seen altered in position in different films and were probably not in the kidney.

*Cystoscopy*: The bladder and ureteric orifices were entirely normal. A catheter was passed up the right ureter without difficulty. Retrograde pyelography demonstrated a fistula between the pelvis and duodenum. A considerable quantity of sodium iodide collected in a rounded mass in front of the kidney. A small quantity of barium was given to localize the stomach and duodenum and it was thought that the rounded shadow seen was the duodenal cap.

FIRST OPERATION (Jan. 15, 1953).—Anæsthetic, pentothal, flaxedil, gas and oxygen.

Through a right renal incision the kidney was explored. It was firmly fixed to the duodenum anteriorly and in attempting to separate the two a large ulcer crater was opened. The kidney was removed. The first and second parts of the duodenum were found to be shortened, the pylorus being at the upper end of the ulcer. The duodenum was closed transversely with a single suture line, and covered with perirenal fat and capsule. The wound was closed with drainage.

THE SPECIMEN.—Examination of the kidney showed a deep ulcer crater in the anterior wall 5 cm. in diameter and approximately 1 cm. deep. Injection of fluid into the ureter demonstrated a minute opening leading from the middle calix through renal substance into the ulcer. The kidney was otherwise normal.

Post-operative progress was uneventful. A fractional test-meal done on the twelfth post-operative day showed no excess of free or total acid and no other findings of pathological importance.

| | 30 *min.* | 60 *min.* | 90 *min.* | 120 *min.* |
|---|---|---|---|---|
| Free acid | 20 | 30 | 25 | 50 |
| Total acid | 30 | 40 | 30 | 60 |

The patient was discharged from hospital on the twentieth post-operative day and asked to report four weeks later.

ON READMISSION.—He reported that he felt better but complained of intermittent epigastric pain unrelated to meals. There was no urinary frequency. The renal scar was well healed. Tenderness was present in the epigastrium.

A fractional test-meal now showed an excess of free and total acid.

| | *Fasting* | 30 *min.* | 60 *min.* | 90 *min.* | 120 *min.* |
|---|---|---|---|---|---|
| Free acid | 85 | 40 | 60 | 75 | 60 |
| Total acid | 100 | 50 | 70 | 100 | 80 |

A barium meal showed delayed filling of the duodenum. The cap was deformed and narrowed and there appeared to be a diverticulum in the second part. There was some obstruction in the third part of the duodenum relieved in the knee-chest position. The findings were consistent with a duodenal ulcer or with post-operative scarring.

SECOND OPERATION (March 19, 1953).—Anæsthetic, pentothal, flaxedil, gas and oxygen.

The abdomen was explored through an upper midline incision, the intention being to perform a vagotomy and limited gastrectomy. A large ulcer was felt in the posterior wall of the duodenum and the pylorus was drawn downwards and backwards towards this making it almost inaccessible. Transhiatal vagotomy with a posterior gastrojejunostomy was therefore performed.

Convalescence was uneventful and the patient was discharged on the twelfth post-operative day. A fractional test-meal on this day showed some reduction in both total and free acid.

| | *Fasting* | 30 *min.* | 60 *min.* | 90 *min.* | 120 *min.* |
|---|---|---|---|---|---|
| Free acid | 60 | 35 | 30 | 40 | 35 |
| Total acid | 85 | 60 | 35 | 50 | 40 |

On April 17 a follow-up barium meal was carried out revealing satisfactory function of the anastomosis. The duodenum was not filled.

FIG. 387.—Retrograde pyelogram, right side, showing filling of cavity in front of kidney and partial filling of duodenum by sodium iodide.

FIG. 388.—Retrograde pyelogram, right side, with superimposed barium meal. Pyloric antrum leads directly to top of round opacity filled with sodium iodide in front of kidney.

Subsequent progress has been satisfactory and the patient is symptom-free.

## DISCUSSION

This case has been reported in detail because of its rarity. It seems from a consideration of available evidence that the primary pathology was in the duodenum and was a peptic ulcer. Whether this ulcer was in fact within a diverticulum of the second part of the duodenum is not clear, for the duodenum had been considerably distorted by fibrosis around the ulcer before the first X-ray examination, and by operative interference in addition before the second. At the first examination the sodium iodide pooled in the large ulcer crater on the anterior wall of the kidney and there was then no evidence of a diverticulum. At the first operation the posterolateral wall of the duodenum was closed transversely so that the first part was pulled downwards and laterally and in the subsequent X-ray picture this manipulation could have been responsible for a pseudo-diverticulum. Whether or not a diverticulum was present, the peptic ulcer was associated with hyperchlorhydria and the vagotomy and gastrojejunostomy directed at this has relieved symptoms and lowered the acidity. The diagnosis presented some difficulty because it was felt that in the presence of a fistula, greater disturbance of the urinary tract was likely to occur than was in fact the case. In view of the rapidity with which duodenal contents attack the skin in a cutaneous fistula, it seemed surprising that the bladder and ureteric orifice should look so normal. This can only be explained by supposing that the fistula had recently occurred, was very tiny, and that leakage occurred only when there was considerable difference of pressure on the two sides as was the case during the retrograde pyelography.

The author is indebted to Dr. H. C. Ho for the radiological examination; to Professor Charles Wells for having brought one reported case to his notice; and to the Department of Pathology of the University of Hong Kong for photographic illustrations.

## REFERENCES

CAPON, N. B., and WELLS, C. (1938), *Arch. Dis. Childh.*, **13**, 85.

SHANKS, S. C., and KERLEY, P. (1950), *Textbook of X-ray Diagnosis*, 2nd ed., **3**, 191. London: Lewis.

# STRANGULATED FEMORAL HERNIA IN AN INFANT BOY AGED FIVE WEEKS

By BETTY M. L. UNDERHILL, London

## INCIDENCE

Femoral hernia in children is a very rare condition. Herxfeld (1938), in her review of 1000 cases of hernia in children under 12 years old, found only 4 femoral lesions, 3 in girls and 1 in a boy. Rutherford (1927) quotes 5 examples, making 0·4 per cent of the 1098 cases of hernia admitted to the Belgrave Hospital for children between 1908 and 1927; and Lloyd (1931) found only 1 case among 715 cases admitted to Great Ormond Street in a period of three years. Of Rutherford's cases, 4 were in girls and 1 in a boy, 4 on the right side and 1 on the left. In his *Surgery of Childhood*, Sir John Fraser says that he has "never met with an instance of the error in a male child".

A search of the literature has revealed reports of only 4 instances of strangulation of a femoral hernia in a child under 10 years old—those quoted by Biasini (1936), Innocenti (1946), Shepler and Smith (1940), and Temple (1952). The youngest patient was a girl of 9 weeks old reported by Shepler and Smith. The case to be described is thus of some interest as it occurred on a male infant 5 weeks old at the earliest age on record.

## CASE REPORT

Peter S., aged five weeks, was admitted to hospital at noon on March 20, 1954, because of abdominal pain accompanied by a swelling in the right groin, first noticed that morning.

The child, a first baby, was born on Feb. 13, 1954, the expected date of delivery being Feb. 24. He was a normal child weighing 5 lb. 14 oz. His mother fed him for twelve days, but when she went home from hospital weaned him gradually onto Cow & Gate half-cream milk, this change being completed two days before admission to Chase Farm Hospital.

He was well and flourishing for the first three weeks of his life until March 10 when he began to strain at stool. He passed no motion for four days. On March 14 he passed four stools, each accompanied by an attack of screaming and straining. There was no swelling in his groin when he was put to bed.

At 5.30 next morning the infant screamed and vomited. His mother could not persuade him to take his food and she noticed that he had developed an obvious swelling in the right groin.

On arrival at hospital he was found to be a small, poorly nourished baby weighing 6 lb. 3½ oz. (a gain of only 5½ oz. in five weeks). His skin tone was normal and there was no evidence of dehydration. He vomited approximately 2 oz. of frothy fluid. The abdomen was not distended and there was no rigidity or guarding. Bowel sounds were loud and tinkling. In the right groin there was a tense irreducible swelling 1 by 1½ in. in size passing down into the scrotum. The rectum was empty and there was no blood on the examining finger. There was no straining on micturition.

It was not possible to feel the pubic tubercle or determine its relation to the swelling, so a presumptive diagnosis of strangulated inguinal hernia was made.

Treatment.—Operation was begun at 2·45 p.m. some 12 hours after the swelling had first appeared. The child was bandaged to a crucifix and was given brandy which he sucked with apparent relish from a finger. The inguinal region was infiltrated with 10 mil of 0·25 per cent xylocaine and an incision was made over the swelling parallel to the inguinal ligament. Owing to the child's very small size, and to the injected anæsthetic, the identification of anatomical structures was difficult and tedious. The inguinal canal was opened, disclosing only a normal cord with no trace of a sac. It was then realized that the mass was a femoral hernia which had passed medially into the scrotum. The lower skin-flap was separated downward and a purple sac exposed as it emerged from the femoral canal. The thick-walled sac turned upward over the medial end of the inguinal ligament, then down into the scrotum, where it was firmly adherent. When it was finally delivered, the spermatic cord and a purple testicle were closely applied to its medial aspect.

The sac was opened and disclosed a little straw-coloured fluid and about 2 in. of strangulated small bowel. The femoral canal was minute and the use of any sharp instrument seemed highly dangerous so the lacunar ligament was gently torn from below by the index finger. As the strangulation was relieved, the baby began to cry and a further 2 in. of bowel obligingly prolapsed; hence the lines of constriction in both afferent and efferent loops were well exposed. Hot wet packs were applied and oxygen was administered through a face mask. Almost immediately the bowel became pink and a peristaltic wave passed over the strangulated segment. The gut returned easily to the abdomen and the peritoneum was closed. No attempt was made to repair the femoral canal. The viability of the testis was in doubt for some minutes, but eventually its colour improved and it was replaced in the scrotum together with the adherent portion of sac wall. The incision was closed in layers and a small drain was inserted for 24 hours.

Bowel sounds were never absent and the child took his food normally that night. His bowels were open next day and he was discharged on the second post-operative day to avoid the risk of cross-infection.

His mother brought him three days later for the removal of stitches. His wound was healed and his weight had increased to 6 lb. 8½ oz. A transparent Avlonyl (nylon film) dressing was applied and affixed with waterproof strapping. One week later this dressing was dispensed with as the wound was healed and dry. The baby had gained a steady one ounce a day since operation and then weighed 7 lb. 1½ oz.

Differential Diagnosis.—The most obvious differential diagnosis is the one actually made, strangulated inguinal hernia. When the swelling lies in the groin rather than in the scrotum, inguinal adenitis will come to mind; indeed Biasini's case was so diagnosed and was treated for some time by poultices before operation. Femoral ectopia of a maldescended testis and psoas abscess should be easily excluded.

## DISCUSSION

There has been much discussion as to the congenital or acquired nature of the sac in femoral hernia. This is a matter of some importance, since simple extirpation of a congenital sac should suffice for cure, but repair of the ring is likely to be necessary if the sac is acquired.

Battle thought that the sac was congenital, and Murray (1910), in a thorough review of the subject, points out that the neck is narrower than the fundus, a condition unlikely to obtain if the sac is the result of intestinal pulsion. He suggests that the femoral

tail of the gubernaculum may become attached to the peritoneum and pull it out into a dimple. The finding of striped muscle-fibres attached to the fundus of a hernial sac he examined gave support to this view, since the appearance closely resembled that of the normal gubernaculum. Tasche (1932), in opposition, expresses the view that "femoral hernias are relatively uncommon before the age of twenty and probably have never been seen before the age of two".

There can be little doubt, however, that the sac in our case was congenital. The thickness and adherence of the wall showed that it had been present for some time, while the child's failure to thrive and the repeated attacks of pain and constipation suggest that there had been minor herniations of bowel for at least ten days before operation. The onset of these attacks coincided with the change from breast to bottle feeding, an event which is frequently associated with peristaltic disturbances which may have forced the bowel into the hernial sac. The pressure of the mass in the groin must have stretched the spermatic artery and vein and caused the marked testicular congestion.


## SUMMARY

A case is presented of strangulated femoral hernia in a male infant 5 weeks old. The strangulation was successfully relieved by operation. The sac was almost certainly congenital in origin.


Thanks are due to Mr. Max Pemberton, under whose care the child was admitted, for permission to publish this case, and to all the surgical team for their help.

## REFERENCES


BIASINI, A. (1936), *Rif. med.*, **52**, 1618.
FRASER, J. (1926), *The Surgery of Childhood.* London: Edward Arnold.
HERZFELD, G. (1938), *Amer. J. Surg.*, **39**, 422.
INNOCENTI, M. (1946), *Polyclinico (sez. Prat.)*, **53**, 892.
LLOYD, E. I. (1931), *Brit. J. Surg.*, **18**, 657.
MURRAY, R. W. (1910), *Ann. Surg.*, **52**, 668.
RUTHERFORD, R. (1927), *Lancet*, **2**, 498.
SHEPLER and SMITH, C. W. (1940), *Amer. J. Surg.*, N.S. **49**, 375.
TASCHE, L. W. (1932), *Arch. Surg., Chicago*, **25**, 749.
TEMPLE, J. L. (1952), *Lancet*, **1**, 594.


# *REVIEWS AND NOTICES OF BOOKS*

**Illustrated Review of Fracture Treatment.** By FREDERICK LEE LIEBOLT, A.B., M.D., Sc.D., LL.D. Attending Surgeon in Charge of Orthopedics, New York Hospital. 10 × 6¾ in. Pp. 229 + x, with 605 illustrations. 1954. Los Altos, California: Lange Medical Publications. $4·00.

THIS is a practical book with over six hundred drawings illustrating the various causes of different forms of fracture and their treatment.

The author discusses briefly and systematically the principal features concerning the diagnosis and treatment of fractures.

The book in fact is an illustrated synopsis of the causation and treatment of fractures. It does not in any way pretend to be comprehensive or detailed, but it should prove of real value to the student, house surgeon, and general practitioner.

Lee Liebolt writes in a refreshing manner and the numerous illustrations are excellent and original.

---

**Maxillo-facial Laboratory Technique and Facial Prostheses.** By STANLEY BRASIER, Chief Technician, Prosthetic Laboratory, Plastic Surgery, Burns and Jaw Injury Centre, St. Lawrence Hospital, Chepstow, Mon. With a Foreword by Sir WILLIAM KELSEY FRY, C.B.E., M.C., F.R.C.S., M.D.S., F.D.S. R.C.S. 9½ × 6 in. Pp. 232 + xi, with 291 illustrations. 1954. London: Henry Kimpton. 31s. 6d.

THIS is a text-book for students and a reference book for all who are interested in jaw injury and plastic surgical appliances. In this traumatic age there is a constant demand for special splints and plastic prosthesis.

Mr. Brasier has written a very practical book which is the outcome of a matured experience as a skilled technician in a busy plastic and jaw injury centre.

Sir Kelsey Fry, who writes a foreword, says: "This book is a reminder to us of the invaluable and essential part played by technicians in a Maxillo-facial Unit."

This monograph should prove not only valuable to students but to all who are concerned with the construction of metal or plastic splints, moulds, obturators, skull plates, and facial prostheses.

As a reference volume it will be valuable as it is the only book of its kind in existence.

---

**Surgical Infections.** *American Lecture Series*, No. 170. By EDWIN J. PULASKI, M.D., D.M.Sc. (Surgery), Lieutenant-Colonel, Medical Corps, United States Army. Edited by MICHAEL E. DE BAKEY, M.D., and R. GLEN SPURLING, M.D. 9 × 6 in. Pp. 332 + xviii, with 10 illustrations. 1954. Springfield, Ill.: Charles C. Thomas. (Oxford: Blackwell Scientific Publications.) 55s. 6d.

THIS is a very useful book, for the author points out that the advantage of antibiotics should not surplant sound surgical measures. The newer antibiotics and their individual uses are described and their method of administration and their possibilities of harm.

There is an extended consideration of thermal burns and the author's experience in the Far East and at the Brooke Army Hospital enriches his opinions.

Surgeons would do well to read this book, for it gives them concise and practical instructions as to the value of the various antibiotics in the treatment of surgical infections.

---

**The Painful Phantom.** Psychology, Physiology, and Treatment. By LAWRENCE C. KOLB, M.D., Section of Psychiatry, Mayo Clinic, Rochester, Minn. 8½ × 5½ in. Pp. 50 + x. 1954. Springfield, Ill.: Charles C. Thomas. (Oxford: Blackwell Scientific Publications.) 11s.

THIS is a short but interesting monograph devoted to the psychology, physiology, and treatment of the painful phantom limb.

After reading this book one is bound to admit the real value of psychiatric treatment in these cases. The illustrated clinical cases are very convincing and of real interest and value to all who have the treatment of amputee's who suffer from a painful phantom.

---

**The Anatomy and Surgery of Hernia.** By LEO M. ZIMMERMAN, M.D., Professor of Surgery and Co-chairman of the Department of Surgery, Chicago Medical School; and BARRY J. ANSON, Ph.D. (Med. Sc.) Professor of Anatomy, Northwestern University Medical School. 10 × 6¾ in. Pp. 374 + x, with 204 illustrations. 1953. London: Baillière, Tindall, & Cox Ltd. 76s. 6d.

PROBABLY the surgical treatment of inguinal hernia is one of the commonest operations performed both at home and abroad. It is also said that such operations on the whole are badly executed because they are performed by house surgeons and registrars.

This book is the outcome of the combined experience of a surgeon and an anatomist, and some new original drawings of the various approaches to abdominal herniæ have been incorporated in the volume.

We would agree with the authors when they consider that no operation in surgery more rigidly demands the exercise of the utmost surgical finesse and technique than does the repair of a hernia.

Although there are several books devoted to the treatment of the various forms of external herniæ yet there is room for this modern up-to-date book which, besides being a very practical volume, gives an excellent bibliography of the works of the past.

---

**Varicose Veins.** By R. ROWDEN FOOTE. Second edition. 9⅝ × 6½ in. Pp. 285 + xii, with 200 illustrations. 1954. London: Butterworth & Co. Ltd. 55s.

THE second edition of Mr. Foote's book has been brought up to date and the improved methods of stripping have been incorporated.

The book should prove of value both to students and practitioners, for it gives in detail various forms of treatment which may be adopted for a very common condition.

---

**Surgery of the Cæcum and Colon.** By STANLEY AYLETT, M.B.E., M.B., B.S., B.Sc., F.R.C.S., Surgeon the Westminster Hospital Teaching Group (Gordon Hospital); etc. 9⅝ × 6¾ in. Pp. 295 + viii, with 142 illustrations. 1954. Edinburgh: E. & S. Livingstone Ltd. 45s.

THIS monograph is the first to be published dealing with the surgery of the large bowel and it is written in a refreshing and stimulating manner by a general surgeon who has devoted much time to this type of surgery.

Mr. Aylett's operative technique is very clear and descriptive and therefore readily understood.

The illustrations, the majority of which are original, and particularly the black and white drawings, are uniformly good throughout the book.

Perhaps the best feature of the book is the detailed and practical description of the pre- and post-operative details of the various operative procedures which are carried out for various colonic conditions.

This book should prove of real value not only to pre- and postgraduate medical students but also to that large group of young surgeons who require a book of this calibre for ready reference.

Mr. Aylett has certainly written a very readable and practical monograph which we are certain will be read extensively by all who are interested in the diseases of the colon.

**Carcinoma of the Colon.** *American Lecture Series*, No. 189. By LELAND S. MCKITTRICK, B.S., M.D., F.A.C.S., Clinical Professor of Surgery, Harvard Medical School; etc.; and FRANK C. WHEELOCK, jun., A.B., M.D., F.A.C.S., Assistant in Surgery, Massachusetts General Hospital and Harvard Medical School. 8½ × 5½ in. Pp. 94 + viii. 1954. Springfield, Ill.: Charles C. Thomas. (Oxford Blackwell Scientific Publications.) 23s. 6d.

THIS small monograph of less than one hundred pages gives in a pithy manner the accepted treatment of carcinoma of the colon as carried out in the Harvard school. This treatment differs little from the accepted procedure as practised in England. Perhaps the most useful part of the book is that devoted to operative technique; this is not only well described but it is well illustrated.

This book is one of the American Lecture Series and it contains in a small space much practical data which will prove of value to the abdominal surgeon.

---

**Textbook of Chiropody.** By MARGARET J. MCKENZIE SWANSON, B.Litt., F.Ch.S., Co-founder of Edinburgh Foot Clinic and School of Chiropody. Second edition. 8½ × 5½ in. Pp. 268 + viii, with 160 illustrations. 1954. Edinburgh: E. & S. Livingstone Ltd. 22s. 6d.

THE second edition of this well-written and concise monograph will prove of real value to the practitioner who is so often faced with painful foot ailments.

There can be little doubt that a close co-operation between doctor and chiropodist is all to the good of the patient.

---

**Demonstrations of Operative Surgery.** A Manual for General Practitioners, Medical Students, and Nurses. By HAMILTON BAILEY, F.R.C.S., F.A.C.S., F.I.C.S., F.R.S.E., Emeritus Surgeon, Royal Northern Hospital; etc. Second edition. 8½ × 5½ in. Pp. 387 + xii, with 538 illustrations. 1954. Edinburgh: E. & S. Livingstone Ltd. 24s.

WE are glad to see the second edition of this very useful and practical guide on operative surgery. It fills a definite gap in the essential books which the modern medical student and nurses require.

It is a vital book for general practitioners, medical students, and nurses, for they will all benefit by reading it.

A very important feature of the book is the number of really good illustrations, which are first-class.

Hamilton Bailey is a born teacher and he has given of his best in the second edition of this book.

---

**Anatomy, Regional and Applied.** By R. J. LAST, M.B., B.S. (Adel.), F.R.C.S., Professor of Applied Anatomy, Royal College of Surgeons of England; etc. 9¾ × 6½ in. Pp. 665, with 309 illustrations. 1954. London: J. & A. Churchill. 55s.

IT is always refreshing and stimulating to read a book which presents a new approach to anatomy and Professor Last has certainly given us this. He has written a book in which he has placed emphasis on general principles to illustrate why structures are arranged in a definite manner. He has also included a large number of original illustrations, many of which come from his own pen.

So many text-books of anatomy go through edition after edition with little alteration and many of the illustrations are dated.

Students, both undergraduate and postgraduate, will find this book a very valuable one, for it will last a lifetime and be a useful reference volume when they are qualified

and want to refresh their memory on any anatomical detail.

Throughout the book Professor Last has stressed the practical side of anatomy and this is a great asset to the modern student. His background of many years of general surgery has enabled him to write an excellent book on regional and applied anatomy.

We congratulate the author on a very fine work.

---

**Cancer, Diagnosis, Treatment, and Prognosis.** By LAUREN V. ACKERMAN, M.D., and JUAN A. DEL REGATO, M.D., Director, Penrose Cancer Hospital, Colorado Springs, Colo. 9¾ × 6¾ in. Pp. 1201, with 702 illustrations. 1954. London: Henry Kimpton. £8 10s.

THE second edition of this large work has in part been rewritten and thoroughly revised and many new illustrations have been added.

It represents the current views on cancer in the United States and one is struck with the overall figures for cancer which make dismal reading. It seems that with the exception of skin cancer and cancer of the colon all other cancers give few five-year cures.

The volume is a large, heavy one, and it is to be hoped that when the third edition is published it will appear as two volumes.

---

**The Anatomy of the Bronchial Tree.** With Special Reference to the Surgery of Lung Abscess. By R. C. BROCK, M.S. (Lond.), F.R.C.S. (Eng.), F.A.C.S., Thoracic Surgeon to Guy's Hospital; Surgeon to the Brompton Hospital. Second edition. 9¾ × 6¼ in. Pp. 243 + viii, with 157 illustrations. 1954. London: Oxford University Press. 45s.

THE second edition of this well-known and important work has been thoroughly revised so as to incorporate the standard international nomenclature. Some new illustrations have been added and there has been considerable extension of the original text.

The monograph is of great importance to the modern anatomist and it is to be hoped that medical students will be taught more and more about the bronchial tree while studying anatomy, and not as usually obtains at present during their clinical years.

Thoracic surgeons and all surgeons who are interested in the surgery of the chest will find this book their guide, philosopher, and friend.

Brock has contributed probably more to our knowledge of the anatomy of the lung than any other living person, and he deserves our best thanks.

---

**Roentgen-diagnostics.** By H. R. SCHINZ, W. E. BÆNSCH, E. FRIEDL, and E. UEHLINGER. First American edition, based on the fifth German edition. English translation arranged and edited by JAMES T. CASE, M.D., D.M.R.E., Professor Radiology Emeritus, Northwestern University Medical School, Chicago. Volume IV, Gastro-intestinal Tract, Gynæcology, Urology. 7¾ × 10⅝ in. Pp. 3099–4029, with illustrations Figs. 3762–4780. 1954. London: William Heinemann (Medical Books) Ltd. £15.

THIS large tome is the fourth and final volume of this comprehensive and monumental work by German radiologists. There are nearly one thousand pages of text and a similar number of illustrations, and the volume has its own index.

X-ray diagnosis in itself plays an important part in every branch of medicine and surgery to-day, and the truly wonderful radiographs in this volume are a source of inspiration to any reader. We in England should ask our radiologist friends to produce similar results for us.

This work comprising four large volumes is the greatest. contribution to X-ray diagnoses which has so far been written.

It will remain the reference work on this subject for many a year.

---

**Surgical Forum. Proceedings of the Forum Sessions Thirty-ninth Clinical Congress of the American College of Surgeons, Chicago, Illinois, October, 1953.** By various authors. 9½ × 6 in. Pp. 752 + xxxvii, illustrated. 1954. London: W. B. Saunders Co. 50s.

IT is difficult to do justice to this publication in a brief review. As Dr. Ravdin has written in the Foreword, "Every surgeon will find in this volume material of real interest", for it ranges over most specialties. Yet its greatest value lies in the description of the scientific investigation of a large number of surgical problems which, though technically specialized, are of interest to all surgeons because the science on which the investigations are based is common to all surgery.

The subject-matter has been carefully selected and grouped under section headings: Heart and Great Vessels; Circulation; Lungs; Œsophagus, Stomach, and Intestine; Liver; Burns and Renal Function; Wounds and Infections; Cancer and Steroids; and Plasma Expanders. A very valuable feature of this volume is the brief but comprehensive introduction to each group of papers which has been written by a well-known master of the subject in hand. The whole forms a fascinating display of current surgical research, and testifies to the apparently inexhaustible stores of surgical enterprise and endeavour which when tested by laboratory methods can be made available to the surgeon and translated into practice.

---

**Tumours of Lymphoid Tissue.** By GEORGE LUMB, M.D., Reader in Pathology, Westminster Medical School, Lecturer in Pathology, Institute of Basic Medical Sciences, Royal College of Surgeons of England. 9¾ × 6¼ in. Pp. 204 + viii. Edinburgh: E. & S. Livingstone. 37s. 6d.

THIS is a most useful monograph written by a pathologist who is in constant touch with surgeons and who has been able to see and observe a large number of tumours arising in lymphoid tissue.

Sir Stanford Cade who writes a Foreword to this monograph, is candid in his praise, for he says "This book should remain for a long time a standard work on the pathology and natural history of tumours of lymphoid tissue". We heartily agree with this statement, for Dr. Lumb has presented the profession with a very readable book full of information which is based on clinical experience. The illustrations are excellent, especially the microphotographs. There can be no doubt whatever that this book contributes greatly to our knowledge of tumours of lymphoid tissue. We should like to congratulate Dr. Lumb on his great contribution to pathology.

---

**Proceedings of the First World Conference on Medical Education, London 1953.** Held under the auspices of the World Medical Association. Edited by HUGH CLEGG, Editor of the *British Medical Journal*. 9½ × 6 in. Pp. 8044 + xvi. 1954. London: Oxford University Press. 60s.

THIS large volume of some eight hundred pages contains the numerous papers which were read at the First World Conference on Medical Education which took place in London in August, 1953. Under the able presidency of Sir Lionel Whitby, every facet in the teaching of medicine

was discussed at length. This book may be said to be made up of the various contributions of the principal speakers and, therefore, is an up-to-date work on medical education.

There can be no doubt whatever that the conference was first-rate and that knowledge on medical education was disseminated, for over 600 men and women, representing 127 faculties and 62 countries, came to London to teach and to learn.

The problems of the balanced curriculum, medical statistics, and the design of experiment, method and value of interview, use and value of intelligence and aptitude tests, and visual aids in education were but a few of the subjects discussed.

As a reference volume this book will be extremely useful, and Universities, Deans of Medical Schools, and medical men and women will find much to interest them in its pages.

---

**Sympathikus Chirurgie.** By Prof. Dr. PAUL SUNDER-PLASSMANN, Director of the Surgical Clinic, University of Munster. 7¾ × 11 in. Pp. 162 + viii, with 146 illustrations. 1953. Stuttgart: Georg Thieme. DM. 54.

THIS beautifully printed and illustrated book gives an account of the surgery of the sympathetic nervous system—about half the book is concerned with its histology, and herein perhaps lies its greatest interest.

The author's views on the histology of the sympathetic system are somewhat unorthodox. He rejects the classical formal conception of nerve-endings and of the synapse, and he uses photomicrographs, which are unusually clear and well reproduced, to demonstrate that the nerve-endings have a reticular form and are so disposed that they make close protoplasmic contact with the cells they supply. He also holds that in connexion with these reticuliform nerve-endings, there are mesenchymal cells which probably secrete chemical substances, making up a neurohormonal system which enables it to function locally to some extent even when separated from its parent ganglion cell. Similarly, in considering synapses, he thinks there is protoplasmic continuity between the ganglion cells, and he postulates a "Nebenzell-plasmodium" between the endings which again has the capacity to produce chemical substances essential for conduction. This conception is at least very interesting, and may help in understanding some of the results of sympathectomy which badly need explanation.

The rest of the book is orthodox, if optimistic, and again operation procedures and anatomy are extremely well illustrated. He recommends for pain, and after trauma, the trial of repeated novocain block, and in some cases of cerebral thrombosis he has had good, though not perfect, results from novocain block and cervical sympathectomy. Contrary to the opinion of most surgeons in this country, he holds that sympathectomy is of use in Sudeck's disease.

Some of his recommendations, which by some would be regarded as a little controversial, would be more convincing if supported by a series of case histories showing late results. For instance, he still uses sympathectomy in the treatment of megacolon and approaches the presacral plexus by a sacral route.

The book is written in a rather involved style which makes it difficult to follow if one is not very familiar with scientific German, but the earlier part of the book is well worth some effort even to those for whom the rest is familiar ground.

---

# *BOOK NOTICES*

*[The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest to our readers.]*

---

**William Clift.** By JESSIE DOBSON, B.A., M.Sc., Recorder of the Museum, Royal College of Surgeons of England. 8⅝ × 5½ in. Pp. 144 + viii, with 31 plates. 1954. London: William Heinemann Medical Books Ltd. 21s.

**The Surgery of Pulmonary Tuberculosis.** By JAMES H. FORSEE, A.B., B.S., M.D., F.A.C.S., F.A.C.P., Colonel M.C., U.S. Army; Chief, Surgical Services, Fitzsimmons Army Hospital, Denver, Colorado. 9½ × 6¼ in. Pp. 208, with 59 illustrations. 1954. London: Henry Kimpton. 48s.

**Trattaments del Malato Chirurgico.** Fisiopatologia e Clinica dell 'Operato. By Prof. LUIGI IMPERATI, University of Sassani. With a Foreword by Prof. LUIGI TORRACA, University of Naples. 9½ × 6½ in. Pp. 684 + xviii, with 116 illustrations. 1953. Naples: Casa Editrice V. Idelson. L. 7000.

**Die Bewegunsbestrahlung.** By Doz. Dr. F. WACHSMANN and Doz. Dr. G. BANTH, University of Erlangen. 9½ × 6⅝ in. Pp. 192 + viii, with 124 illustrations. 1953. Stuttgart: Georg Thieme. DM. 36.

**Die Teleröntgentherapie.** By Prof. Dr. W. TESCHENDORF, Cologne. 8½ × 5¾ in. Pp. 72, with 8 illustrations. 1953. Stuttgart: Georg Thieme. DM. 8.70.

**Die Wirbelsäulentuberkulose und ihre Differentialdiagnose.** By Priv.-Doz. Dr. J. E. W. BROCHER, Genf. 11 × 7¼ in. Pp. 272 + xii, with 376 illustrations. 1953. Stuttgart: Georg Thieme. DM. 78.

**Die Technik der Blutgruppen- und Blutfaktoren-Bestimmung.** By Prof. Dr. P. DAHR, Göttingen. 8 × 5¼ in. Pp. 320 + viii, with 27 illustrations. 1953. Stuttgart: Georg Thieme. DM. 24.

**Zeitloses und Zeitgebundenes in der Chirurgie.** By Prof. Dr. R. NISSEN, Basel. 8½ × 5¾ in. Pp. 36. 1953. DM. 2.

**Die Nahbestrahlung.** By Prof. Dr. H. CHAOUL, Berlin, and Doz. Dr. F. WACHSMANN, Erlangen. 9½ × 6¾ in. Pp. 225 + xii, with 304 illustrations. 1953. Stuttgart: Georg Thieme. DM. 39.

**Klinische Fehldiagnosen.** By Prof. Dr. M. BÜRGER, Leipzig. 9⅜ × 6⅝ in. Pp. 480 + xii, with 209 illustrations. 1953. Stuttgart: Georg Thieme. DM. 58.50.

**Grenzen des Normalen und Anfänge des Pathologischen im Röntgenbilde des Skelettes.** By Prof. Dr. A. KÖHLER. Ninth edition revised by Doz. Dr. E. A. ZIMMER, Bern/Fribourg. 10½ × 6¾ in. Pp. 672 + xii, with 1282 illustrations. 1953. Stuttgart: Georg Thieme. DM. 88.